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ABSTRACT

In this era of rapid social change, educational administrators have discovered that new approaches to problem solving and decision making are needed. Systems analysis could afford a promising approach to administrative problems by providing a number of systematic techniques designed to sharpen administrative decision making, enhance efficiency, and increase the probability of educational program effectiveness. Several system models for rational decision making have been developed by business, military, and industrial organizations. Each of these models depends upon an operational definition of the desired result, a specification of the processes designed to achieve that result, and evaluative techniques to assess the success of each process. School districts and administrators would benefit from the implementation of one or more of the rationalistic decision-making techniques such as planning-programing-budgeting system, critical path analysis, or operations analysis. Once goals are chosen, these techniques aid in proper resource allocation to effect those goals. (RA)

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Administrative Technology & the School Executive

Applying the Systems Approach to Educational Administration

Submitted by the
AASA Commission on Administrative Technology

Edited by
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AASA is pleased to acknowledge and express its appreciation for the efforts of those persons and others, such as Mrs. Roslyn Neuman of the AASA secretarial staff, in the production of this report and other activities of this Commission.

FOREWORD

No man is an island—and no profession can remain isolated from the ferment in its environment. To remain a viable force in education, administrators must be sensitive to new developments and be capable of adapting the relevant technology of the era to their tasks. The American Association of School Administrators recognizes the promise technology holds for the improvement of practice and some years ago organized a series of commissions to study and recomment prudent courses of action. This is the second report of an AASA commission concerned with narrowing the gap between technology and the practice of school administration.

The AASA Commission on Administrative Technology was created in January 1966. Its objectives were to identify recent developments in administrative technology in other fields, determine the feasibility of adapting what has been successful elsewhere to school administration, and facilitate dissemination of concepts of the new administrative technology that are pertinent to the profession.

School administrators, beset on all sides by requests for change, discovered that traditional approaches to problem solving and decision making often fall short of satisfying new demands. This is not intended as a criticism of existing practices; most were not designed to cope with the unique problems now confronting chief school executives. The same experiences were noted in business, industry, and government, and for similar reasons executives in these fields turned to the promise of technology. Technology is no cure-all. It is concerned with the generation of a set of systematic techniques and organized knowledge applicable to the practical tasks of mankind. It demands the expenditure of additional effort and self-discipline on the part of those who use its new ideas, procedures, and tools to administer more effectively.

As responsibilities increase and become more complex, school administrators will have to intensify the search for technology that will help in the resolution of issues. The intellectual technology based on systems and the machine technology based on the computer will necessitate new ways of thinking. In addition, the modern educational decision maker will have to comprehend the special language and techniques of cost-effectiveness analysis, systems planning, operations research, simulation, and computer-based information systems to reduce uncertainties and ensure a higher probability of effectiveness.

AASA is grateful to the men of this Commission who labored beyond the call of duty in a very new, difficult, and complex field. They can be likened to trailblazers opening new vistas. The application of systems concepts and procedures to education as described herein required a creative approach. Little existed in education that simply could be reviewed and condensed. This Commission accepted a creative challenge and developed a report that will serve as a milestone. It deserves the careful study of all who seek to become more effective leaders, decision makers, and executives in education.

FORREST E. CONNER
Executive Secretary
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School Administrators

CHAPTER 1

Coping with the Challenges

New ways of doing things, whether as pedestrian as self-service in retail stores or as sophisticated as systems analysis, are the hallmark of the last half of the twentieth century. It now takes little time to move an idea from the laboratory to the marketplace, and what is more, people demonstrate a greater readiness to accept radical modifications in the operations of most institutions.

The rate of technological change has been uneven from decade to decade and from century to century. This does not mean that it developed in an erratic fashion. The 1966 report of the National Commission on Technology, Automation, and Economic Progress confirmed the common belief that events were moving faster. Some contend technological change continues at an exponential rate. Case studies of major technological innovations demonstrate that the typical period between a discovery and recognition of its commercial potentials was reduced from about thirty years prior to World War I to sixteen years between the wars, and to only nine years after World War II. Furthermore, the lag in converting a basic technical discovery to its initial commercial application has decreased from about seven years to five years.[1] Where potential for consumer use is evident, development and diffusion of the innovation is nearly twice as fast as compared with purely industrial applications.

New ideas upset established procedures; this in turn unsettles the people who designed the procedures, adjusted accordingly, and learned to live with them as standard operations. A substantial part of the social ferment in our culture can be traced to rapid acceptance of the products of technology by some and not others. The lead time available for smooth adjustment within a social institution to a technological development has been shortened dramatically. It almost seems as if we scarcely comprehend and adjust to one innovation before being confronted with another. Education is one of the many major social institutions in present society that is caught up in the ferment complicating life in the late twentieth century.

Education and Change

Education is also a prime factor in stimulating conscious social change. Through the learning process the capabilities of the creative can be sharpened to better focus the power of disciplined thought and scientific experiment on human challenges. The systematic exploitation of pure science, coupled with technical know-how, has given birth to a steady flow of new approaches, fresh designs, and unique products. An educational system which helped the fertile mind reach its potential should be neither surprised nor alarmed by the consequences of its success. Schools that really make a difference in society must accept the turbulent world their creative graduates helped to produce. It would be most incongruous if educational systems were to stand still or, worse yet, fight change. Unfortunately, the application of technological change to educational systems has been erratic over time and very uneven as to place.

There are other compelling reasons for the acceptance of change. Schools are being asked to contribute more to the resolution of an ever-growing number of complex social, economic, and political problems. The burdens placed on schools are growing in number and complexity. More and more, people are turning to educational institutions to help solve the great social problems of our times, whether these be breaking the cycle of poverty, developing racial harmony, or ensuring continued economic growth. But it is not enough to see the institution as the long-range solution. Impatience with the slowness and resoluteness with which the schools respond to social problems is manifested through protest, unrest, and sometimes violent disruptions. The United States achieved its greatness, and in large measure sustains its position, through the ingenuity, education, and industry of its people. For it is through an educated citizenry that our nation has harnessed the blessings of its bountiful resources for the improvement of mankind. No nation can carry men to the moon's surface and bring them back safely without an educated citizenry that plans and supports such achievements.

Necessity is the mother of invention, but technology is the father of change. Widespread public recognition of the influence of technology on our way of life assumes that it is, by and large, beneficial. Most people point to the impact technology has had on bettering working conditions by eliminating many dirty, menial, and servile jobs; by shortening working hours and extending leisure time; and by providing a growing abundance of goods and new products. New interests and experiences add more zest to life. On the other hand, technology raises fears and doubts as well. It can upset delicate environmental balances and generate problems such as air and water pollution, urban blight, and excessive depletion of natural resources. Uprooted people are often the price of technological change, and the social costs of such dislocations cannot be ignored. As the National Commission on Technology put it: "Technology has, on balance, surely been a great blessing to mankind—despite the fact that some of its benefits have been offset by costs." [2]

Administration and Technology

Traditional approaches to the administration of public education are based on the technology that existed when the tradition began. In other words, some type of technology has affected administration and other processes in education through the years. The problem is that current educational practices may reflect the state of knowledge and technical achievements of 20 to 50 years ago. Processing data in pupil accounting, financial accounting, and other types of school records at the turn of the century could be done efficiently by well-organized manual labor with little help from the cumbersome and costly machines in existence at that time. Manual approaches and relatively unsophisticated planning techniques were fairly satisfactory when the rate of change was relatively slow, growth in school enrollments modest, social problems fewer in number and lesser in intensity, and the people patient. These conditions no longer prevail. Rising expectations demand more sophisticated capabilities. What is more, it is no longer necessary to remain chained to the tired and less effective approaches. Data processing need not be confined to manual approaches or machines rendered obsolete by new inventions. Each year there is less and less justification for drowning in data or for failing to have available information pertinent to prudent decision making.

Technology has affected all aspects of human life; educational institutions are no more immune to its social consequences than other institutions. More and more the question is asked, if the present-day technology can benefit business and commercial activities, why can it not be adapted to benefit school administration? The pressures to replace the old methods with the current technology, and to overcome many problems in educational organization as a result, continue to mount. What the alternative responses of the field should be in the face of such demands is what this book is all about.

This is not intended to be a volume on technology per se. It will focus on current technology available to aid the administrator in his efforts to cope with the challenges confronting educational institutions. It will emphasize what can be called administrative technology, which, for the purposes of this volume, means the recently developed technologies that can be applied to the administration or management of organized institutions. This AASA Commission was charged with the responsibility of identifying and describing technologies developed for other fields that could be adapted to the administration of educational institutions. There were relatively few guidelines in the literature of the field and even less in current practice to direct Commission efforts or to simplify its challenges. This volume is a point of departure in the development of what could be a new and exciting era in school administration. It is not concerned with definitive answers or descriptions of completely developed technological applications for educational administration. The state of the art does not permit this. The Commission's main thrusts are to sensitize the profession to the almost unlimited potential of the new technology and to stimulate the creative adoption of new inventions to the purposes of educational administration. A basic assumption is that technology will redefine the role of the school administrator. In so doing it will enable him to reorder priorities and reallocate energies in his usually overcommitted schedule. It exacts a price, for those who seek to take advantage of any new technology must acquire new skills and insights.

This report to the membership comes at a time when educational administration is on the verge of experimenting more boldly with new technologies. Admittedly there may be more talk than actual implementation, but oral commitments are often a prelude to more complete involvement. Many know well the rhetoric of innovation and technology, but few possess the skills necessary for implementation. For this reason what lies ahead is a discussion of a promise. The Commission's investigation revealed a great deal more conversation than sophisticated applications; more people knew the jargon than were able to describe in detail how a new technology could be adapted and put to everyday use. The Commission discovered quickly that its efforts were best focused on organizing the new concepts in a way that might be meaningful to practitioners and on creatively exploring the possibilities of adapting a new technology to educational administration.

The longest journey begins with the first small steps. Similarly, it may be appropriate to consider this as the report of the "First" Commission on Administrative Technology. The members of the First Commission recommend that in five or at least ten years hence AASA constitute a new group to reexamine the progress in harnessing the promise of technology to the improvement of educational administration.

The promise of administrative technology was perceived as being virtually without limit by this First Commission. It can open new avenues for the all-important task of decision making in a rapidly changing environment; provide valuable assistance in the uses of electronic measurement, automation, and the computer; make available promising new techniques such as cost-effectiveness analysis, systems thinking, operations research, computer techniques for studying uncertainties, data banks, and information retrieval. It gives the school administrator more than ever before the opportunity to anticipate, develop, evaluate—and test—strategies for change *before* putting them to use. In short, it will enable the school administrator—as tomorrow's manager of program and human resources—to systematically exploit the possibilities of pure science and technology in order to control and give immediate direction to planned change.

No school system, regardless of size, can afford to ignore the implications of these developing trends. The chapters which follow attempt to depict those techniques and concepts which were determined by the Commission during more than two years of study to be most pertinent and promising for school administration. Thus, the Commission may be regarded as an exploratory task force on emerging technology that could help school administrators to cope more effectively with the complexity that confronts them. The report which follows should not be regarded as a primer for learning how to apply technological concepts and devices. It is rather a description of administrative techniques with emphasis on the state of the art in the late 1960's. The extent and sophistication of usage will most certainly increase in the immediate years ahead.

Technology as it relates to instruction per se is not reviewed to any great extent. In reporting the Commission's findings and conclusions emphasis has been placed on technology as applied to administration. This should not imply that instruction is of little importance. On the contrary, a special AASA committee is concentrating on instruction and technology and will publish its findings late in 1969. The Instructional Technology Committee report will be the third in a series which began with *EDP and the School Administrator,* followed by the present volume.

Technology and Systems

Technology is derived from the Greek word denoting "systematic treatment." The dictionary defines it as terminology of a particular subject, that is, technical language; the science of the application of knowledge to practical purposes, that is, applied science; or the application of scientific applications with emphasis on practical uses of knowledge. Popular usage tends to equate technology with glamorous and complicated machines. This image is inconsistent with the above definitions which stress techniques and approaches rather than the product of such techniques or the hardware associated with them. Technology, for our purposes here, is a set of systematic techniques and related knowledge; it may or may not call for machines of varying degrees of sophistication. Technology is a means to an end; it is pursued not for its own sake but to solve practical problems. It assumes that the basic knowledge exists and that there is a creative mind that can apply pertinent information to a given situation. Some would equate technology with "educational engineering." For the most part educators tend to react negatively to the term "engineering" as being too rigid and mechanistic for a people-oriented profession. Engineering need not be confined or confused with things inflexible or inhuman.

Following these premises, administrative technology is that set of systematic techniques, which may or may not involve hardware, and related scientific knowledge that can be applied to the practical problems of an administrator. This volume is concerned with the administrator of educational institutions. Again, the emphasis will be on the intellectual dimension (approaches) rather than the physical dimension (machines) of technology. Thus, for the purposes of this volume, administration is perceived more as a process than as the traditional cluster of substantive areas such as finance, plant construction, or laws.

One set of techniques is related to the continuous cycle of administrative activities that begins with defining and ordering objectives for the institution; involves the generation and then selection of alternative ways of reaching the objective; and concludes with the determination of the range of acceptable expectations and subsequent evaluation of progress toward and achievement of predetermined goals. This set deals with functions crucial to administration and is part of what is referred to as "systems thinking." A great deal of space will be devoted to systems as a way of adapting current technology to the problems of administrators.

Systems can make more meaningful the theory movement which started in educational administration during the early 1950's. The systems approach provides a unique perspective for assessing administrative challenges. It can be classified as an approach to thinking that represents a further extension of the scientific attitude and method in administrative problem solving. In another sense, it is the orderly analysis of the differentiated component elements and processes within an organization; the relation of each element and process to the other, and all to the missions of the organization; and the perception of the organization as unified, possessing dynamic qualities, and having defined boundaries. The classic conceptions of the administrative process—planning, organizing, allocating resources, staffing, coordinating, controlling, or evaluating—are not superseded by systems. However, the manner in which each process is perceived and how it is executed take on new dimensions. In systems, the emphasis is on interrelationships.

Systems thinking, sometimes called systems analysis or the systems approach, is growing in popularity. Its beginnings are difficult to pin down with precision. Perhaps it is best to say that its roots can be traced to the first efforts to introduce science into the management of organizations.

This would relate systems to what now seem to be primitive efforts at the orderly analysis and design of shop room production activities by F. W. Taylor around the turn of the century. These were extended by the insightful analysis of the general administrative functions by Fayol. A greater degree of maturity was the result of the human relations focus of the Hawthorne experiments. A new high level was reached with the search for a theory of organizations to describe, explain, and predict the central core of administrative functions. In this sense, systems technology is part of a continuing evolution and represents an even greater degree of sophistication in the application of science to administration. Many disciplines such as economics, mathematics, and sociology have contributed concepts to the systems idea.

Systems has become a prestigious term, and this is not without its dangers. The term may be used to gain some measure of recognition for the user. There may be little concern for its preciseness in describing accurately what the concept means. The difficult task of elaborating on this emerging technology in fairly specific terms is the challenge of the chapters that follow. New approaches to management decision making, such as systems, may be expressed in many ways and applied in a variety of contexts. In addition, a full range of terminology associated with technology has developed as new applications have increased and spread. This has resulted in a lack of standardization of terms, creating difficulty for those interested in identifying and describing the emerging technology. This publication acknowledges the difficulty and has attempted through its glossary, bibliography, and selection of descriptive examples to offer the reader conceptions and definitions most meaningful and appropriate to school administrators.

Certainly there is a new language to be learned. This is imperative if any degree of sophistication in comprehending or creating new concepts, techniques, and procedures is to be achieved. Technology is being increasingly applied by many of the business and government agencies with whom the schools must interact. Local programs supported by state and federal agencies are being planned, organized, and evaluated through the use of models, operations research, and cost-benefit analyses. The school administrator who comprehends and can employ skillfully systems concepts will enjoy a more beneficial relationship with agencies that seek more sophisticated evaluations of projects or a more precise determination of the accountability of the institution. The reader should not assume, however, that the superintendent must possess all specialized systems skills or competencies and personally execute quantitative analysis. Rather, the implementation of the new technology will be undertaken by the superintendency—not one man, but a cluster of personnel, some of whom will possess the more specialized systems competencies. Systems not only calls for an administrative team, but demands a new team configuration.

This report opens the door to an exciting group of ideas—program budgeting, gaming, operations research, PERT, management information systems, to mention a few. They are relatively new to education but hopefully will be an established part of educational administration within a decade. Whether this will be accomplished will depend upon whether leaders in educational administration see their relevance and potential for enhancing the effectiveness of superintendents, assistant superintendents, principals, and others. There are indications that technique and machine developments are emerging faster than human development is capable of implementing them. The propensity to cling to the old technology must be replaced by the more adventurous spirit of trying new approaches.

Other more comprehensive books and documents probe in greater depth each of the concepts and techniques presented in this publication, and these should be reviewed to gain a high level of skill and competence. It is hoped that the chapters which follow will move the practicing administrator beyond the confusion and limited awareness of administrative technology that presently characterizes the state of the art in education. It is but a first step in what must become a massive in-service effort if these new concepts, tools, and procedures are to be disseminated in education in time to help the superintendent in his continuing search for ways of sharpening decision making, coping with conflict, improving human relations, accommodating larger numbers of pupils and programs, and helping students to learn more better and faster. Administrative technology may contribute to the enhancement of each of these concerns.

FOOTNOTES

[1] National Commission on Technology, Automation, and Economic Progress. *Technology and the American Economy*. Washington, D.C.: Government Printing Office, 1966. Vol. 1, Chap. 1.

[2] *Ibid.*

CHAPTER 2

Systems Technology: Some History and Some Basic Concepts

In spirit, the emerging administrative technology based on systems is as old as logical thinking, scientific experimentation, and systematic problem solving. In technique, however, it is as new as the recently developed quantitative analysis models, PPBS, and computer-based information systems. The long-established spirit and the more recently evolved techniques stimulated a "new style of private and public planning, problem solving, and choosing." [1] The new technology may influence all sectors of society and may have applications in many different types of organizations. By the late 1970's the future-oriented, mission-focused technology may be recognized as a salient characteristic of the American culture.

As implied in the previous chapter, technology evolves from basic knowledge, generated or identified by creative minds. Such knowledge may be ordered, objective, and precise, as in the case of algebraic concepts, or less so, as in some of the nonmathematical concepts related to economics. In either instance the applications of systems analysis lead to decisions which can be accepted with varying degrees of confidence. The result may be simply a new arrangement of unknowns or variables within a special model of a problem situation. On the other hand, it could lead to the design of a new invention with properties superior to those of existing gadgets.

Greater emphasis in this volume will be placed on what is called intellectual technology than on what is known as machine technology. Both have value and can contribute to the resolution of some perplexing problems in school administration. What is more, the two types are at times difficult to separate and differentiate. Thus, the implementation of a new approach may demand the utilization of sophisticated machines such as computers to gain optimum effectiveness. Whatever the type of technology and whatever the area to which it is applied, certain demands are placed upon the would-be user. Where it is to be used to enhance organizational decision making, the technology may require the administrator to produce a more precise definition or clarification of objectives in operational terms, more highly organized and carefully analyzed data that shed light on the goals, more explicit formulation of educational programs and procedures, more accurate indicators and measures of organizational outputs, and more careful weighing of the consequences of alternative proposals than would be the case in the traditional approaches to decision making. This new intellectual technology related to the art and science of rational decision making is the basic substance of what is called the systems approach. It is a new way to frame and to analyze complex problems demanding a decision. Its recently developed techniques represent a more precise and disciplined approach to problem solving.

Decisions reached through the application of current technology may be quite different from choices arrived at in a less sophisticated manner. One reason for this is that the systems approach employs specialists from a number of diverse fields to provide unique inputs in the analysis and planning stages. Secondly, the rules of procedure are more systematic and precise and, therefore, decisions based on these applications will better withstand critical and rational inquiry. Thirdly, the emphasis on the generation of models and the insistence on gathering pertinent facts replaces pure intuition, emotional predispositions, and visceral judgments based on incomplete data. Systems technology has power to the extent that it produces a solid, objective, rational basis for decision making. The result is more effective control over operations and greater capability to cope with the bewildering array of new possibilities.

There are limitations to the conceptualization of the systems technology in the preceding discussions. The systems approach as been evolving over the last three decades in a variety of contexts. It is expressed in many different ways. There is a need for a taxonomy which would help clarify basic concepts. The proliferation of terms, with differing shades of meaning, complicates the task of identifying and describing the emergent technology. Confusion in terminology is understandable at the present primitive stage of development. Some have likened the confusion in terminology that presently accompanies technology to the facetious evaluation made of Richard Wagner's music by one wit, namely, "it's not as bad as it sounds."

A review of the historical development of the new technology will help us to better comprehend its basic concepts and applications. Systems technology has been around in various degrees of sophistication during the last 30 years in military, industrial, governmental, and educational organizations. Some of the major and historic applications of the new technology in differing types of organizations and concepts common to the various implementations will be described briefly in the paragraphs that follow.

A BRIEF HISTORY OF THE NEW DECISION TECHNOLOGY

Systems technology is only beginning to be tested in education after three decades of experience in other settings. The first recorded efforts to implement it are credited to the British military immediately prior to and during World War II. It was referred to at that time as "operations research." As that term implies, problem solving starts with an analysis of operating data, in this case certain military operations. Industry demonstrated an interest in operations research immediately following the end of World War II and subsequently developed applications unique to it. Government agencies followed suit, initially the U.S. Department of Defense and then other federal departments and agencies. State and local government units, including school districts, were among the last to employ it.

The British Military and Operations Research

In the late 1930's the military establishment in England sought the assistance of British scientists to adapt the recently developed radar technology to military purposes. One problem was detecting and tracking unseen enemy warplanes. Radar was then a laboratory curiosity. The initial objective was to determine the maximum distance an aircraft could be detected by means of radar. From that simple beginning the team of British scientists moved to register one of the most dramatic and widely publicized success stories in the annals of science. They went beyond improvement of early-warning radar systems to radar control of antiaircraft gunnery. The scientist-military teams applied operations research techniques to design more efficient antisubmarine warfare, improved accuracy for airplane bombing, and improved patterns of deploying ship convoys to minimize losses from German U-boats. In some cases, the approach called for the adaptation of a scientific invention (such as radar) to a military problem, but in others (such as deployment of ships in a convoy) there were no machines, only an intellectual analysis of operations. Of significance to school administration is the fact that military practitioners turned to teams of experts in science to seek a solution to a vexing problem. More often than not a team of experts is necessary to resolve the many facets of a complex issue. School administrators might give serious consideration to consulting with experts in other fields as one way of bringing the promise of new technology to educational operations.

By 1939 the activity was recognized formally and acquired first the title of "operational research" and later "operations research." The name was derived from the fact that the first efforts focused on the *operational* use of radar and were executed by scientists who formerly were involved in radar *research*. Other terms were generated as well. Among these were "operations analysis" and "operations evaluation." Although the military use of "operational research" did not end with the cessation of hostilities, the desperate need for such analysis was obviously diminished, and the techniques were moved to other areas. Many operational research workers transferred to industries in Britain and the United States after World War II.

The precise beginning for any new movement is difficult to pinpoint. Some argue that Thomas Edison did operations research for the U.S. Navy during World War I. Others point to the efforts by F. W. Taylor in his scientific management approach, the time and motion studies by Gilbreth in U.S. industry, or the planning methods by Gantt to record progress in construction as the early beginnings of the movement. It is true, however, that nothing on the scale noted in Britain in the late 1930's had been attempted earlier. The degree of sophistication of techniques and the size and number of team scientists would qualify Britain as the place and the late 1930's as the time of origin for the present-day conceptions of operations research.

Industry and Systems

The new techniques spread slowly at first to the nationalized coal, electrical, transport, and steel industries of England. By the late 1950's there were numerous industrial applications of operations research in Great Britain. The new decision-making technology began to receive serious consideration from industrial and business leaders in the United States about 1950. The first conference on operations research in the United States was held at the Case Institute of Technology in Cleveland in 1951. Business administration at that time was where educational administration is today insofar as systems technology was concerned. There were few U.S. industrial case studies which could describe the impact of the implementation of the new systems technology. The paucity of experience and literature forced business leaders to turn to military examples to illustrate how the new decision-making techniques worked. Education is now repeating this experience as its leaders in systems turn to military and business examples to describe the potential powers of systems administration.

By 1960 approximately one-third of the 500 largest corporations in the United States employed some techniques of operations research. Whenever a new specialization is born, the founding of a new professional society is not far behind; to illustrate, the Operations Research Society of America was established in 1953. As the new technique spread to industrial establishments, a number of things happened. First, scientists and engineers representing different disciplines began to emphasize one interpretation of the technology or one set of techniques as opposed to another. It was inevitable that many applications would result in operations research being viewed from a much broader perspective. Nonmathematical approaches began to emerge as well. At first a variety of new terms were generated to describe similar processes. Finally, the writers began to focus on one which has maintained its popularity thus far, namely, "systems." It triggered a new family of concepts. Among these were "systems analysis," "systems design," "systems management," "systems planning," and "systems control." These new systems concepts spread rapidly during the next two decades to replace the older "operational research." But the objective remained that of improving decision making by adapting a new intellectual technology.

Systems technology is dynamic, so that the broadening of experiences and further reflection produced more applications and further refinements in established techniques. Heavy emphasis on quantitative analysis in the resolution of the problem situation was retained, if not expanded. Mathematics gave the movement greater objectivity and sharper analytical powers. Experience revealed that even though the product manufactured by one firm was different from that of another there were many processes that were similar. For example, managing inventories of supplies and equipment, allocating resources to various organizational functions, sequencing and scheduling work within the institution, routing personnel and material through a territory, maintaining and planning replacements for materials and equipment, and arriving at prudent decisions would be of concern in business, industry, government, hospitals, military operations, and even schools. The relative importance of these functions may vary in each type of institution. Nonetheless, if operations research could optimize solutions to inventory control, resource allocation, and the like in one organization, it could do the same for another. If the focus is on basic processes rather than unique products, a greater transfer of techniques may be possible than was recognized previously.

Electronic computers made it possible to manipulate larger volumes of data and to retrieve such data in a relatively short period of time. Operations research is based in part on a variety of data and data manipulation, but advanced mathematical analysis may consume a great deal of time if processed manually. Computer technology extended the range of operations research technology. This is only one illustration of how an advance in one technology may influence the operation of another.

The U.S. Department of Defense and Systems

A new chapter in the use of systems techniques in government began when Robert McNamara became Secretary of the Department of Defense (DOD). In 1961, in collaboration with his assistants A. C. Enthoven and Charles Hitch, the new decision technology was applied to a number of defense problems. It was believed that the systems approach ("systems analysis" was the preferred term in DOD) could overcome many existing planning inadequacies within the Defense Department. The new approach at the Pentagon replaced a decision-making process which some described as being largely "a process of bargaining among officials and groups having diverse strengths, aims, convictions, and responsibilities."[2] The purpose of systems, as McNamara viewed it, was to facilitate a more deliberate choice of goals, a more systematic relating of means to ends, and more precise evaluations of the outcomes of given programs. It was in DOD that the term "planning-programming-budgeting-system" (PPBS) had its origin. This was the more or less official designation for a process of rational decision making. It is difficult to separate it from systems analysis or the systems approach.

Evaluation of programs and alternative means spawned other concepts such as "cost-effectiveness analysis" and "cost-benefit analysis." One of the problems confronting those acquiring an interest in the new technology is how to separate one term from another. Many writers have difficulty differentiating between operations research systems, PPBS, and cost-benefit analysis; others don't even try, implying they are synonymous concepts for all practical purposes.

The controversy and skepticism which surrounded McNamara's "Management Revolution" has been well publicized. It is also widely recognized that he and his assistants did create a system of decision making which had an important impact upon the Defense Department, its components—the Army, Navy, and Air Force—and even Congress. The new approaches to decision making and patterns of organization and staffing appear to be destined to survive the departure of McNamara from the Department of Defense.

Applications in Other Federal Agencies

Approximately four years after the new system of decision making was established in DOD, the stage was set for new thrusts. In the summer of 1965 President Lyndon B. Johnson announced that the planning-programming-budgeting-system (PPBS) would be required in all federal agencies and departments. He believed the system to be very new and very revolutionary, one which could achieve three major objectives: it could help find new ways to do jobs faster, better, and less expensively. The President emphasized that PPBS could produce more accurate information and suggest which federal programs should be emphasized and which should not.

A few months after the President announced his recommendation of PPBS, the Bureau of the Budget issued a bulletin addressed to all federal agencies and executive departments which directed personnel to begin consideration of PPBS. Each agency was requested to develop a permanent and specialized staff with analytic capability to execute in-depth studies of objectives and of various programs to meet agency missions; a multi-year planning and programming procedure along with a system of gathering data that would aid agency heads and the President in making major decisions; and a budget process which would translate program decisions into more refined budget planning and provide relevant program and financial data for presidential and congressional action.

During the last two years much energy has been expended by federal government personnel in seeking to understand and to operationalize PPBS. Much remains to be done at this writing. However, in President Johnson's 1967 Budget Message to Congress various uses of PPBS were reported in disease control, child health care, urban planning, agricultural research, and tax administration.

Systems in State and Local Governments

Federal government stimulation of PPBS generated interest in state and local government. For example, PPBS was attempted for a period in the State of Wisconsin. Terry Sanford, who developed the idea of the Institute on State Planning, made the following observation: "The national commitment to land a man on the moon by the 1970's has uncovered an incredible array of new techniques and devices. The design of a 'guidance system' for state government is one of the central tasks of the Institute."[3]

The application of systems management techniques at the state and local government levels is being stimulated as well by large aerospace corporations serving as consultants on governmental problems. These corporations are seeking ways to apply the know-how developed in defense and space projects to nondefense commitments. Some are "marketing" their systems analysis and planning skills in the hope such services will be applied to the solution of social problems. To illustrate, one large aerospace firm recently designed a 10-year plan for improving and updating data processing for the State of California. The design, if implemented, will support a number of state planning activities including those associated with education. Another studied waste management in California within the context of the next 25-35 years. The objectives were to define the major elements of a waste system, assess the applicability of systems analysis to a problem of this complexity, and delineate the research and development required to improve air pollution control and other kinds of waste management during the next quarter of a century. A third industrial firm applied systems techniques to certain aspects of transportation in California. This involved simulation of complex transportation systems of the future. The impact of such factors as changes in living and transportation habits, goods manufactured and then transported, and technology for moving people from one location to another were reviewed. In a fourth case the new decision-making technology concentrated on applications in handling juvenile delinquency and projected alternative courses of actions with regard to this important area. Cost-benefit analyses have been conducted to show the results of ignoring problems as opposed to undertaking specified action.

Municipal governments are moving to gain competence in applying the new decision-making technology to the persistent problems of large urban centers. Early in 1968, for example, Mayor John Lindsay announced that his office was entering into a contract with a private concern to employ systems in an effort to design improved operations for New York City police, fire, health, and housing departments. He added that the agreement would assist in the introduction into city agencies of the kind of streamlined modern management thinking that was applied in the Pentagon. He regarded this as a most important development in the search for effectiveness in city government. He declared that a special office would be created and staffed with economists, sociologists, engineers, cost analysts, and other researchers to work full or part-time on problems with various city departments. The projected systems department was to examine such problems as police communications and deploying manpower; predicting locations of fire and deploying manpower; predicting the effect of new programs such as Medicaid and developing research programs; projecting building deterioration; and making market analyses of future needs.

Early in 1968 it was revealed that a U.S. corporation with systems capability had entered into a contract with the government of Greece to apply systems technology to the problems of that nation. Some described this as a most unusual and potentially far-reaching agreement between a government and a private enterprise. It was anticipated that the project would require 12 years of work. The company agreed to analyze the economic potential of Crete and Western Peloponessos, with the goal of attracting investment in these areas. It was hoped that the new technology plus management know-how would help uncover Greek development opportunities in tourism, industry, and agriculture. To illustrate, special attention is being given to the advantage of Greece's year-round growing season; the corporation is using the systems approach to evalute European markets to find where and in what month each item of produce will bring the highest price. A similar effort is being expended to identify which form of transport can bring each item to market most efficiently. The U.S.-based corporation will use special offices in Brussels, New York, and Washington, D.C., as well as its corporate network in 30 nations, to seek investments to transform its recommendations into dams, factories, and hotels.

Applications in Education

During recent years the number of uses of the new decision techniques in education has increased. This chapter will simply identify some major applications in education. More extensive reviews and adaptations to school administration will be presented in subsequent chapters.

The new technology has found its most extensive application in educational administration thus far in the scheduling and sequencing of complex projects such as construction of school plants. The "Program Evaluation and Review Technique" (PERT), for example, has been used in a number of school districts and state education departments, as has the closely related "Critical Path Method." These approaches call for the breakdown of complex projects into specific units or events. The activity required to reach a given milestone in the complex project demands a definite period of time for completion. Each step along the way can be related to another to produce a time schedule of work activities. The so-called PERT network schedule prepared in advance can be used to systematically monitor the work process to ascertain whether the project is on schedule or whether shifts in resource allocations are necessary to bring it back on schedule.

Another application of the systems technology has been the location of sites for area vocational schools. A predictive model was developed incorporating such factors as high school enrollment in the area, total civilian population in the area, administrative support structure, and financial support capability. Tests of the model, which encompasses 13 different factors, showed it to be more economical than most other methods of locating area vocational schools.

Cost-benefit analysis techniques have been applied to education with more limited success. One writer, for example, used selected techniques to analyze recommendations set forth in 1965 by the Educational Policies Commission to the effect that public-supported two-year colleges should be established to accommodate all students desiring free education during their thirteenth and fourteenth years. As a result of the analysis he determined that if the Commission recommendations were put in effect, many less well-prepared students would attend two-year colleges, costs would be 10 percent higher for these students, and the incremental earnings of the students would be only half the amount accruing under existing standards.

Finally, it should be noted that an increasing number of aerospace companies and "hardware-software" complexes interested in education are beginning to apply aspects of the new administrative technology to educational problems. For example, one corporation, with the aid of a U.S. Office of Education grant, recently applied concepts of systems analysis to information problems in an effort to develop ways to speed up the transmission of needed data to secondary schools. Various new education industries are also attempting to use new techniques in their efforts to create new products and services of use to public school systems.

CONCEPTS UNDERLYING SYSTEMS ANALYSIS AND PPBS

Since systems analysis and PPBS will be developed in greater detail in later chapters, only introductory and relatively brief descriptions will be given here. In the discussion of underlying concepts, the term "systems analysis" will refer to industrial applications; "planning-programming-budgeting-system" to the more recent applications in government; and "systems approach" to possible applications in education. This implies that the three terms are synonymous, but there are some advantages in recognizing certain shadings in meaning which derive from the differing applications.

A System Orientation

The key word is "system," and it appears in both systems analysis and PPBS. It implies a synthesizing or unifying thrust and interrelationships between elements in contrast to studying specific variables in isolation or as fragments of the total. Problems are reviewed in a total system context with special emphasis on interactions between elements.

As noted in the early military problems, the application of radar to early detection of aircraft could not be viewed simply in terms of where to locate radar equipment. Other factors in the early detection system included the creation of a communication network to disseminate the discovery by radar, the protection of the communication system, the training and assignment of personnel in the total system, and the linkage of the radar and communication systems with the military response capabilities, that is, the unleashing of the antiaircraft batteries or defense fighters. Instead of conceptualizing and resolving a problem in one part of the administrative system, the emergent technology typically involves definition and redefinition of the issues as various dimensions of the system are reviewed and as understanding is gained about how one part of the system interacts with others. In other words, the system approach to the resolution of a problem represents an effort to grapple with the full complexities of the situation in which business, government, and educational managers find themselves. It reaffirms the well-known statement that the whole is greater than the sum of its parts.

Heavy Reliance upon Facts or Data

The new technology demands data from the real world. Facts must be identified, analyzed, and then interpreted in a rational and creative way. They are important in the conceptualization of the problem and the generation of alternatives for its resolution. Reliance on authoritative decrees or special ideology is deemphasized.

Because facts play a central part in the method, organizations consistently using systems analysis and PPBS have often found it necessary to design and create unique information systems to support analysis efforts. As will be seen in the next two chapters, management information systems are basic to the new decision technology. In analyzing complex problems, a wide variety of data is generated and analyzed. This is often beyond the capability of manual data-processing approaches. Computer-based electronic data processing becomes imperative as a tool rather than as an end in itself in systems analysis. The nature of the problem and the extent to which quantifiable applications are required and can be achieved largely determine the extent of computer use in systems.

Focus on the Future

PPBS, systems analysis, and the systems approach are planning oriented and concerned with a future-time perspective that goes far beyond one year hence. They seek to find ways to reduce the negative impact of uncertainty about future events. Systems analysis as an analytical procedure may encompass shorter time periods than PPBS which tends to emphasize intermediate and long-range time periods in decision making. Systems analysis can be applied to a variety of problems related to the efficient allocation of existing facilities and resources. PPBS is typically oriented to programming which will require resources not yet allocated. This means that when systems analysis is applied to various classes of problems, the objective is efficient management to achieve already established purposes. The Program Evaluation and Review Technique (PERT), for example, was used initially to ensure that the Polaris missile system would be efficiently developed. The same technique has been used in education to help ensure the efficient building of a community college. PPBS, as a later chapter demonstrates, is concerned more with policy formation and longer-range objectives. In DOD an eight-year planning period is the bench mark for program projections with opportunities to review and change plans annually. Fiscal planning to achieve programs is based upon a five-year period. Because of the longer time perspective of PPBS it is concerned more with the generation of program ideas and with making judgments about unallocated resources than with administering already funded programs.

In planning for the future, it is necessary in both short-term and long-range time perspectives to give careful study to organizational objectives or outputs and to be as clear as possible about them. This obviously is easier within a short-range framework. It is also easier in industrial applications where the measures of system output can be clearly defined in terms of dollars. Because objectives and outputs are obviously more difficult to stipulate within the governmental area, including education, it is also more difficult to establish ways which clearly maximize objectives with given resources or which minimize resource use in the attainment of given objectives.

Teams of Specialists

Another common element of systems analysis, PPBS, and the systems approach is the special character of the personnel employed in the process. It is difficult to predict when a given specialty or how many different types will be needed in defining a problem or in designing solutions relevant to complex systems. Teams of specialists, therefore, often become a necessity. Thus, the analysis of the economic aspects demands the talents of economists. Sophisticated quantitative analysis calls for the insights of mathematicians or statisticians. Psychological or sociological implications within a system require still other types of specialists. In the systems attack on a situation, it is not unusual that a variety of specializations are employed.

Teams of scientists are usually of an interdisciplinary character and their members must interact with administrators and policy makers in the system under consideration in order to be effective. Thus, PPBS, systems analysis, and the systems approach are pragmatic in orientation. Insights of scholars are joined with the perceptions of administrative and other actors within the system under study. The final results are designed to provide the manager and policy maker better bases for making decisions and for controlling the shape of future events.

Simulation and the Use of Models

In the case of systems analysis especially, there is the assumption that organizational systems cannot be controlled in their original environments; therefore, scientific experimentation in the classical research sense cannot be achieved. An important strategy for coping with this situation is to represent reality through conceptual and mathematical models and to seek to understand it through symbolic representations. Systems analysts, in other words, experiment with reality through the use of abstract symbols. This bears a similarity to astronomy, which obviously has been advanced through controlled laboratory studies. Since the astronomer cannot manipulate the solar system he studies, he builds a representation of it and calls it a model. There are various types of models, ranging from the rather pedestrian physical or small-scale model of the solar system to a sophisticated mathematical model. The mathematical model is an expression of the movement of stars or other phenomena as a series of equations. Within these equations the significant variables are identified, weighting as to importance is attached to each variable, and the interrelationships between variables is described.

Mathematical models are difficult to generate and are even more difficult to interpret to persons lacking in mathematical understanding. All models take the form of an equation in which a measure of the system's performance (P) is equated to some relationship (f) between a set of controlled aspects of the system (C_i) and a set of uncontrolled aspects (U_j). The basic equation for all models, then, is the following:[4]

$$P = f(C_i, U_j)$$

In other words, performance is determined by significant controlled and uncontrolled aspects of the system. In the process of using models it is obviously necessary to determine those aspects of the environment which can and cannot be controlled. Such a determination can lead to the manipulation of variables which can be controlled in order to maximize organizational output in relationship to input.

As already noted, a range of mathematical models has been developed for use by those applying the new decision-making techniques. Programming involves mathematical equations which can resolve a variety of resource allocation problems. A simple illustration of such use can be found in large-scale menu planning. What menus, for example, will meet the criteria of basic nutrient value, a reasonable variety each day and from day to day, and economic efficiency. Quantifiable measures can be developed for each of these criteria, and by the use of programming equations optimal solutions to menu planning problems can be developed.

In many of the applications of systems analysis and PPBS, it is not now possible, particularly in education, to achieve quantified measures of output. Under these conditions, mathematical formulas cannot be used productively. However, concepts and theoretical models, which do not accommodate quantified data in the manner achieved in mathematical models, can still be very useful in guiding systems analysis and in projecting alternative solutions, even though they are less useful in predicting and measuring consequences. Thus, they tend to be analytical rather than predictive tools.

In the final analysis, the results of simulated decision making through either mathematical equations or conceptual models must be tested against the constraints of practice. All predicted results must be confirmed by testing in the real world. The systems analyst must translate equations and data into directions that are meaningful to administrators and other personnel.

Thus, the new administrative technology is responsive to practice. It provides practitioners with a way of controlling and monitoring the consequences of decisions. It also offers scholars unique opportunities to apply concepts and theories to the solution of organizational problems.

One of the major breakthroughs in the use of systems in school administration will come when the administrator begins to develop and use models of the system, or part of it, that is under study. Models can do much to enhance the decision-making skills of practitioners.

Creativity Required

The application of the systems approach, systems analysis, and PPBS obviously requires a high degree of skill and creativity. In systems analysis, for example, much ingenuity is involved in the actual definition of problems and in the discovery of those aspects of the system which have important implications for solving problems. Mechanical or routine applications of the methods cannot lead to effective results. Since systems analysis techniques, by definition, must be uniquely adapted to the setting in which administrators work, the creative use of intelligence is essential. One of the dangers in education now is that systems analysis will not be adapted sufficiently to the context, purposes, and problems of educational institutions.

Much creativity is also involved in the application of PPBS. The conception of program alternatives for future years, for example, is a highly creative activity requiring much inventiveness. Such long-range programming requires the careful analysis of a variety of data and makes demands upon the originality of those who use the method. In both applications, then, one should not expect high degrees of payoff in education unless talented and trained personnel are involved, and they creatively adapt the new techniques to education's goals and settings.

SUMMARY

From what has already been said, it is evident that there are some shades of difference between PPBS, systems analysis, and the systems approach. PPBS is oriented more toward long-range planning and toward the generation of program alternatives. It is less susceptible to complex quantitative analysis and more susceptible to the value dimensions of an applied political context. It also encounters greater difficulty in achieving precise output measures as contrasted with the business applications of systems analysis where the criterion of profit is clearly defined.

It is clear, however, that in spite of the different emphases of the two applications they are closely related in spirit and concept. They seek to define problems by using the all-encompassing concept of "systems"; rely strongly upon data gathering and the careful use of facts which, in turn, requires special management information systems; are oriented toward the future and the control of anticipated events; require teams of specialists involving both scholars and administrative actors in the system under study; utilize, insofar as possible, quantitative approaches and, in some cases, simulation and mathematical modeling; and demand creative behavior on the part of those who apply the new decision-making technology.

Systems analysis and PPBS have been applied in a variety of military, industrial, and governmental contexts during the last 30 years. According to some observers, the new decision technologies have "dehumanizing" effects because they are essentially concerned with matters of efficiency. In addition, there are those who argue that since the new technology tends to deal with values which can be measured and since such fundamental values as human dignity cannot be measured, it may tend to leave out or deemphasize the most important variables in decision making. Finally, the effective application of the method demands much rigor, talent, and time, and its uses in industry, government, and military contexts have not always been productive or successful.

Even though the new technology has limitations, it also offers considerable hope and promise to those in education. It does this by placing a premium upon the use of logic and imagination in organizational decision making. It assumes that decision makers can do much better than they are now doing in controlling organizational consequences and in shaping educational futures. By providing tools for systematically examining the status quo and for projecting ways to go beyond it, it opens the way to greater rationality in educational administration.

FOOTNOTES

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[1] Ways, Max. "The Road to 1977." *Fortune* 75: 93+; January 1967.

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[2] Seligman, Daniel. "McNamara's Management Revolution." *Fortune* 72: 117; July 1965.

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[3] College Station. "A Study of American States." (News Release) *College Station*, January 31, 1967. p. 4.

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[4] Ackoff, Russell, and Rivett, Patrick. *A Manager's Guide to Operations Research*. New York: John Wiley and Sons, 1963. 31 pp.

CHAPTER 3

Administrative Information Technology: Harnessing Data to the Systems Approach to Administration

The increasing complexity of modern school systems by itself has generated a flow of information that threatens to engulf school executives. As stated in the previous chapter, the systems technology calls for tremendous numbers of facts from the real world. These data must be stored, processed, and retrieved as needed. There can be no effective systems administration without efficient means of handling data. No organizational leader can remain effective for long without the basic, comprehensive, and detailed data required to maintain the pulse of the organization and to make prudent decisions. If knowledge is power, then relevant, well-organized, and easily retrievable information is a source of superpower. The problem is complicated by the fact that all too often the pertinent information is poorly processed or organized, tardy in arrival, irrelevant in terms of assigned responsibilities, and presented in a format that fails to reveal important insights. One of the pressing needs in educational administration today is for a technology that will facilitate organizing, processing, and distributing vast quantities of information quickly and meaningfully. In a sense this is a specialized communications problem, that is, disseminating data to the points where it is needed most for effective administration.

What is being referred to more frequently as the information technology is one of the growing number of new disciplines spawned by the knowledge explosion. It implies, literally, that a science has been generated that deals with the handling of data. Handling data means identification, selection, preparation for storage purposes, storage in various storage media, manipulation, and retrieval of information. Facts can be terribly frustrating if left sprawling and uncoordinated within a system. The information technology can be subdivided further in terms of specific functions. "Administrative information technology" focuses on the preparation, storage, processing, and retrieval of student, staff, and other personal records; fiscal records; operational records; and planning records. Others have used "management information system" to describe the preparation, procedures, processing techniques, storage media, and retrieval approaches for data pertinent to administrative decision making. Even earlier the popular terminology was "data bank" instead of "management information system" or "administrative information technology."

Systems as a decision technology rests on a sophisticated data base that demands implementation of an equally sophisticated management information system. The term "management" is synonymous with "administration." The term "administrative information system" means the same as the more popular "management information system." Manual manipulation of data is inadequate to meet the demands of the systems approach. The electronic computer technology made the management information system operationally feasible.

The Computer

It is difficult to conceive of the information technology without computer technology. American business and industrial firms have turned in increasing numbers to the computer, and the electronic data processing made possible by it, to dramatically reduce and simplify clerical work as well as to speed the flow of paper work that surrounds record keeping. The computer has emerged as a comprehensive management tool, indispensable to the application of systems administration. It is difficult to separate the computer technology from the administrative information technology. By the late 1960's the electronic computer had become a commonplace piece of hardware to which was assigned an ever-growing number of tasks related to payroll management, inventory control, and production control. The federal government alone had more than 4,600 general purpose computers in its 1969 inventory. In 1951, it had only three. During the mid-1960's it added computers at the rate of more than 600 per year. Schools cannot match such growth in the use of computers and for that reason have done little to design management information systems.

No one questions the speed, accuracy, and volume of work the computer has been able to perform in the routine and somewhat pedestrian accounting functions. But the computer is something more than a superclerk. It is a device which demands the attention and direction of top-echelon executives. The computer can be conceived as part of an electronic intelligence system. It can be used to examine the viability of alternatives and evaluate the options open to an administrator.

More recently efforts have been made by business and government to harness the full potential residing within the computer by employing it to cope with the more sophisticated aspects of administration. More imaginative and creative uses of the electronic computer were necessary in part to justify the tremendous investment in physical equipment, in computer programming, and in relatively high-salaried computer specialists in programming and information systems analysis. Computers today are performing tasks often assigned to middle and top managers planning future and day-to-day operations of organizations. These new and more sophisticated computer applications related to management control and policy-level decision making would have been impossible without the establishment of a management information system. This orderly evolution from the traditional operational or routine applications to processing and retrieving data relevant to the analysis of alternative courses of action or to the simulation of consequences of one type of decision or strategy as opposed to another necessitated the third-generation computer as hardware and the creative modeling of operations as well.

The earlier publication, *EDP and the School Administrator,* by the AASA Committee on Electronic Data Processing described in detail the evolution and nature of computers. Only a brief review will be attempted in the paragraphs that follow. The initial or first-generation computers were based on vacuum tubes to control the flow of electrical impulses. The many and comparatively large vacuum tubes resulted in the creation of rather bulky equipment. In addition, the heat from the tubes shortened the life of all units in the machines and necessitated air-conditioning of all spaces where the large first-generation equipment was housed. Second-generation computers used small transistors to perform functions previously assigned to vacuum tubes. They generated practically no heat. The important factor was that computers of smaller size could be produced, and such machines processed data faster and more accurately. Transistorized computers experienced fewer breakdowns and were more economical to operate as well. Third-generation computers with monolithic integrated circuitry and thin film memories came on the scene in the mid-1960's. Third-generation hardware is even more compact than its predecessor, extremely fast in processing, and capable of storing prodigious amounts of data at a relatively low cost. At this writing, the fourth-generation computers remain in the developmental stage. They may take advantage of the technology called cryogenics—the production of very low temperatures, for conductors chilled to low temperatures have less resistance to the flow of electricity. This in turn greatly increases the flow of electrons and thus speeds operation.

The computer is an electronic device and processes electrical impulses. This means that numbers, letters, and other symbols which comprise the ordinary elements of communication must be translated into a coded sequence of electrical impulses for machine processing. The reverse occurs when processed electrical impulses are decoded into the symbols intelligible to the ordinary person. Every computer must have an input device to receive information from the outside world, a storage unit to hold in abeyance the data not being processed, a processing unit that manipulates data according to plan, a set of instructions called a program which tells the computer what to do, a control unit to manage the many operations which go on at fantastic speeds, and an output device to print or display the results of the processing. The processing unit is perhaps the most important and is called the "central processing unit," or CPU. Input and output devices may be attached to the CPU. Input for a computer can be in the form of data converted into punched cards or encoded on magnetic tape. The output device may be a fast printer, a visual display unit called the cathode ray tube which looks like a small TV monitor, or a magnetic tape machine which stores the data in tape form.

The operation of a computer requires special machine operators, programmers, and people with special insights into preparing information for the computer. Due largely to third-generation advances, the computer is being brought closer to the user, not by bringing the central processing unit into every office, but by placing input-output terminals connected with, but at some distance from, the CPU in the office or classroom. Some of the most exciting advances in computer technology are occurring in the development of input-output terminals which greatly facilitate the insertion or retrieval of data from the central processing unit where it is stored or manipulated. Someday the computer may be addressed directly by voice contact, but for the present specially coded messages are needed to trigger computer operations.

The technology which moved the electronic computer from the laboratory of the electrical engineer to business, industry, and governmental offices made it possible for the executive to store, retrieve, process, and organize data flows relevant to decision making. The creation of a machine or the fact of an invention represents potential. Something more is required to harness the machine to the purposes of educational administration. That something includes the creation of a management information system, generation of models of the system, and the development of computer programs that relate the data to the models. Of concern here are the dimensions of the management information system. Models are referred to in other chapters of this volume. Computer programming is a special and technical area and is not reviewed in this report.

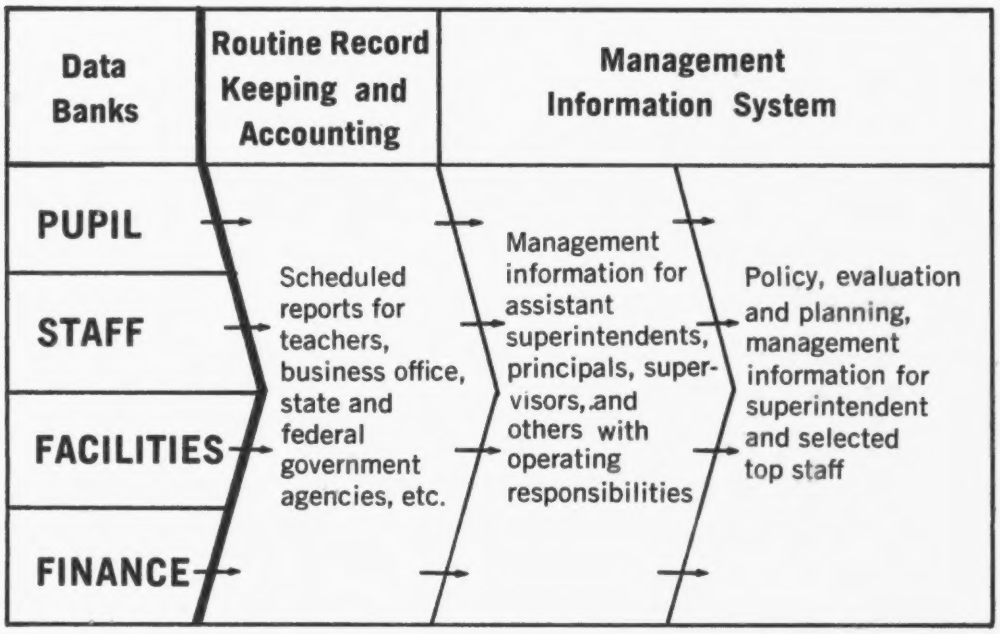
CHARACTERISTICS OF MANAGEMENT INFORMATION SYSTEMS

The administrative information technology calls for the identification and organization of facts essential to the administration of an educational institution, or any type of institution. Administrators have recognized for many years that some types of reports are necessary to gauge the effectiveness of operations. More often than not, these were historical in nature, that is, information gathered after the fact. With manual or mechanical devices this was all that was possible. To illustrate, bookkeeping machines helped to keep track of and organized data on financial expenditures. The storage of fiscal data placed on printed cards required a considerable amount of clerical labor and time. Furthermore, it was difficult to retrieve and even more so to analyze in a variety of ways that could shed some unique light on operations. The electronic computer made it possible to move a variety of data out of a purely historical concept for present use as well as to predict the future.

A management information system can be differentiated from a more broadly based general computer information system. Data in this storage bank is relevant to the school administrative functions. This includes data necessary in the basic functions of planning, evaluating, organizing, controlling, and executing. A general information system knows no bounds. The types of information that could be included are so many as to go beyond the economic storage of data, particularly if something more than routine information and detailed data are required. The present trend is away from one huge data bank of almost impossible size to a series of specialized data systems required for the various specialized branches of a complex institution. These unique special information systems can be placed in the internal or easily connected external storage units of the central processing unit, that is, the main frame of the computer.

It is apparent that a management information system is a subset of the general information system which may be developed for the organization as a whole. The information processing system translates data from the surrounding environment as well as data generated by the system into inputs important to decision making. That data within a general information system considered important to the operation of an organization provides the basis for the management information system. The chart below has been designed to show the relationships between a school system's general information system and its management data base. A school district may have separate information subsystems for pupil instructional records, attendance records, class scheduling, health records, and the like; staff employment assignments, promotion, retirement, and the like; plant construction, maintenance, purchasing, and the like; and/or financial receipts, expenditures, indebtedness, and the like. Each data bank may demand storage of a great number of relevant data elements or facts. The data elements are assembled in a meaningful manner to produce information which is contained in a number of reports for distribution to teachers, the school board, school business

Chart I


Data Banks
Routine Record Keeping and Accounting
Management Information System
PUPIL
STAFF
FACILITIES
FINANCE
Scheduled reports for teachers, business office, state and federal government agencies, etc.
Management information for assistant superintendents, principals, supervisors, and others with operating responsibilities
Policy, evaluation and planning, management information for superintendent and selected top staff

officials, state and federal government agencies, or to other groups which require the information or find it helpful. The reports usually provide routine record keeping and accounting information which satisfies the requirements of the general information system.

To take advantage of the new decision technology, data in the management information system must be structured in imaginative and meaningful ways. It is possible to design a management reporting system which is totally separate from the basic information system, but this project demands its own hardware and software, is costly, and requires considerable lead time for necessary planning. The creation of specialized information banks may be necessary, however, if the management information system demands data which cannot be provided from the general system.

IDENTIFICATION OF INFORMATION CRUCIAL TO ADMINISTRATION

Improved circuitry and enlarged storage capacities for modern-day digital computers are impressive. But the key to implementing computer technology is asking better questions or making better use of the answers relevant to the administration of institutions. There must be a creative conjunction between the transistors of the machines and the purposes of the man in order to enhance the potential residing in any technology. Identification of information and reports relevant to school administration is the first step in the design of a meaningful administrative information system. This is related to the conception of administrative functions; in other words, the new technology demands a more penetrating understanding of basic ideas that were only vaguely understood before. Administration may be defined as a process of defining objectives or missions; organizing; assembling and allocating resources; assuming leadership; and coordinating and controlling. There are other ways to express the administrative process. The more general terms of planning, decision making, executing, and appraising can be used. Middle management is generally concerned with execution or operation of certain divisions of the organized institution. Top-level administration, on the other hand, focuses on development of policy, evaluation of progress toward established objectives, and generation of plans or strategy to achieve objectives.

It is, of course, apparent that school administrators at all levels in the hierarchy require information essential to the achievement of management purposes in order to fulfill responsibilities effectively. The precise nature of reports or organization of information demanded will vary from administrator to administrator and from one echelon to another. School administrators for years have requested and utilized systematic reports; therefore, the basic idea behind the management information system is not new. The computer has opened up dramatic new avenues which would not have been possible to achieve within the manual and traditional forms of data processing. The information technology is relatively new in education. Although the centralized information system which can be used by a number of managers and through which they can communicate has been in operation in business settings for more than a decade, there is considerable evidence that the information technology is still considered unclear, if not somewhat muddled.

Chart II has been prepared to show how a management information system might be developed from a single data bank (in this case, the pupil data bank) for administrators at the school plant level or middle management personnel concerned with instruction, pupil services, attendance, and the like. In the left-hand column the data elements for each pupil are listed. These include the pupil's name, age, sex, address, and a number of other facts. These data elements are used to

Chart II

Pupil Data Bank	Routine Record Keeping and Accounting	Management Information System	
Data Elements for Each Pupil • Name • Birthdate • Sex • Address • Parents—Occupation • Handicaps • Attendance • Teachers • Schools attended • Grades • Standardized achievement test results • Academic aptitude test results • Class sizes • College attendance • College performance (Excellent, Average, Poor) • Degrees	• Mailing list • Attendance reports • Grade reports • Class-size reports	Middle Management Information (Operating Level) • Pupil attendance percentages by class and by teachers • School attendance percentages compared to previous years • Grade summaries by class, subject, and teacher • Summary of achievement test data by subject area • Summary of pupils' academic aptitude by class and by teacher • Summary of class sizes by teacher	Top Management Information (Policy and Planning Level) • Total number and distribution of students • Updated enrollment projections • Significant shifts in pupil attendance • Pupil achievement in subject areas and by grade levels as measured against curriculum objectives • Dropout experience as measured against district objectives • College attendance and performance

prepare class-size reports, attendance reports, grade reports, and so on. The final reports may go to teachers, to the business office, to parents, or to other destinations where the information will be of value.

Under the heading Middle Management Information are a number of reports which might prove to be of value to the principal as well. This information might include the general academic aptitude of each class under a teacher's jurisdiction, a record of class performance, average daily attendance, size, and so on. Since reports will be generated on a periodic basis providing the principal with up-to-the-minute information, he should be in a better position to discern meaningful trends.

Summary reports are usually preferred, but brevity must not obscure meaning or direction. Summaries need not be confined to tables but can be expressed graphically to highlight trends. To reduce further the volume of data which a principal in a very large high school receives, exception reporting can be installed. In this way certain control limits are established, and reports are made only when the indicators exceed the selected limits. For example, in noting class sizes perhaps only those classes with more than thirty pupils or less than twenty would be identified. With regard to pupil attendance the principal might receive information only on classes falling below a selected percentage of daily attendance.

At the top management level the superintendent is concerned with the formulation of policy and the evaluation of progress and planning. The management information system should be programmed to yield the information in a format most likely to enhance the decision-making capabilities of the superintendent. Reports related to the pupil data bank can be organized to show enrollment trends, significant shifts in pupil attendance, and other information essential to district-wide planning. In large-city school districts with mobile pupil populations it is imperative that technology be adapted to help identify quickly the pertinent changes in pupil attendance patterns. Other reports from the pupil data bank might concern pupil achievement, dropout experience, and college performance.

Management reports described in Chart II are generated from a single informal subsystem. Other facts may be derived from each of the various data banks which comprise the district's total information system. This vastly increases the possibilities of producing information in the format necessary for prudent decision making. Reliance on manual procedures to extract this same information would be both time-consuming and costly in terms of clerical assistance required. The computer-supported management information system, once programmed and the operational "bugs" removed, brings together the relevant data quickly in the necessary format and provides the valuable lead time so important to good planning.

POTENTIAL OF THE ADMINISTRATIVE INFORMATION TECHNOLOGY

The improved third-generation computers and peripheral equipment have opened up an exciting array of new possibilities. Among these possibilities is that of placing computer-based data directly at the administrator's fingertips through a telephone line. This system makes use of various kinds of equipment in the administrator's office. Such equipment might range from small, individual, cathode ray tube consoles to large screen systems and various kinds of teletype interrogation consoles. Administrators desiring particular information can ask questions directly of the computer and receive the answers instantaneously, either in the form of traditional printed reports, or by graphics, or by projection of information onto screens for group viewing.

Suppose, for example, that a school personnel administrator had access to on-line equipment which was tied to a well-developed bank of personnel data. Assume further that this administrator needed to know the number of teachers within the system with college majors in foreign languages. He could ask the computer for this information by remote teletype and receive an immediate reply giving the number of employees with such qualifications. If he were then interested in knowing the names of these employees, he could type in the appropriate requests and promptly receive the desired information. Traditionally the need for such information would require that a time-consuming perusal be made of the district's personnel records or that a questionnaire be prepared and circulated to all members of the staff.

Again, this same administrator might be interested in making an analysis of the age, sex, composition, experience, and salary characteristics of the district's teaching staff. This analysis could be made for each subject matter area or grade-level teacher. For example, the computer might be asked to indicate the total number of instructors teaching secondary school English and the breakdown of this total number by sex, average age, years of experience, and salary. Given this same information for each subject matter area, specific recruiting objectives could then be established which would greatly enhance the district's ability to build a more effective staff. Such information might reveal a need to recruit more men in a particular field or a need to balance an aging and experienced faculty group with a number of youthful beginning teachers.

It is also possible with the new on-line systems to modify selected entries merely by typing in the desired changes. For example, assume that it becomes necessary to update employee salary data which is stored in the district's personnel data bank. The computer is notified of changes in employee salary history in a matter of minutes by use of the remote teletype, and the new information is instantly recorded in the computer's files.

Another important capability of recently developed systems is that of time-sharing. This new advance in information processing technology makes it possible for many people to have simultaneous access to a single computer from remote locations. At least one system now under development will enable as many as 60 persons to use the computer at a given time. The implications of this simultaneous multi-use feature for school systems are many. A number of school systems could combine to utilize a single computer, thereby reducing costs and providing the possibilities of data-sharing. Within a large school system, administrators and counselors from many different areas would be able to communicate instantly with the computer from office-based consoles in scattered locations.

Highly sophisticated management information systems are not in common use in education today. In the not-too-distant future they will be. When the time does arrive, it is interesting to speculate as to the changes that will take place in the board rooms of large school systems. The board room will probably be on-line to the computer and contain report interrogation consoles and large-screen, color viewing devices. Administrators will be able to utilize the computer to project information onto the screens in the form of charts which show trends and trend projections. These can then be discussed with board members in relation to the overall plans and objectives of the district.

Other interesting possibilities present themselves as a result of this type of sophisticated management information system. Direct access to the computer has the potential of permitting board members and administrators to experiment with various alternative courses of action. This involves the use of simulation and mathematical models. Through this technique, management can enter various alternative courses of action into the interrogation console, and the basic results of each course of action will be simulated and displayed for viewing in seconds by a trend line or bar chart. This capability has great potential for aiding the decision-making process of boards of education through clarification and through group analysis of alternative courses of action.

While such sophisticated systems are on the way and are indeed already in use in some places, it is likely that the traditional scheduled printout report will be the usual product of management information systems for some years to come. This is particularly true in school systems where the planning and equipment costs of on-line systems will give them low priority in relation to other district needs.

MANAGEMENT FILE SYSTEMS

With each passing year the flow of paper into the superintendent's office has increased until it has reached staggering and unmanageable proportions. New federal and state programs, the quickened interest of private business in education as an expanding market, the broadening research of most professional organizations—all these factors and more have caused the superintendent's office to be deluged with a daily flood of information. And not all of this information comes from external sources. Greater emphasis on research and communication has caused a substantial increase in the internal generation of data, much of which joins the stream of information which is funneled to the chief executive.

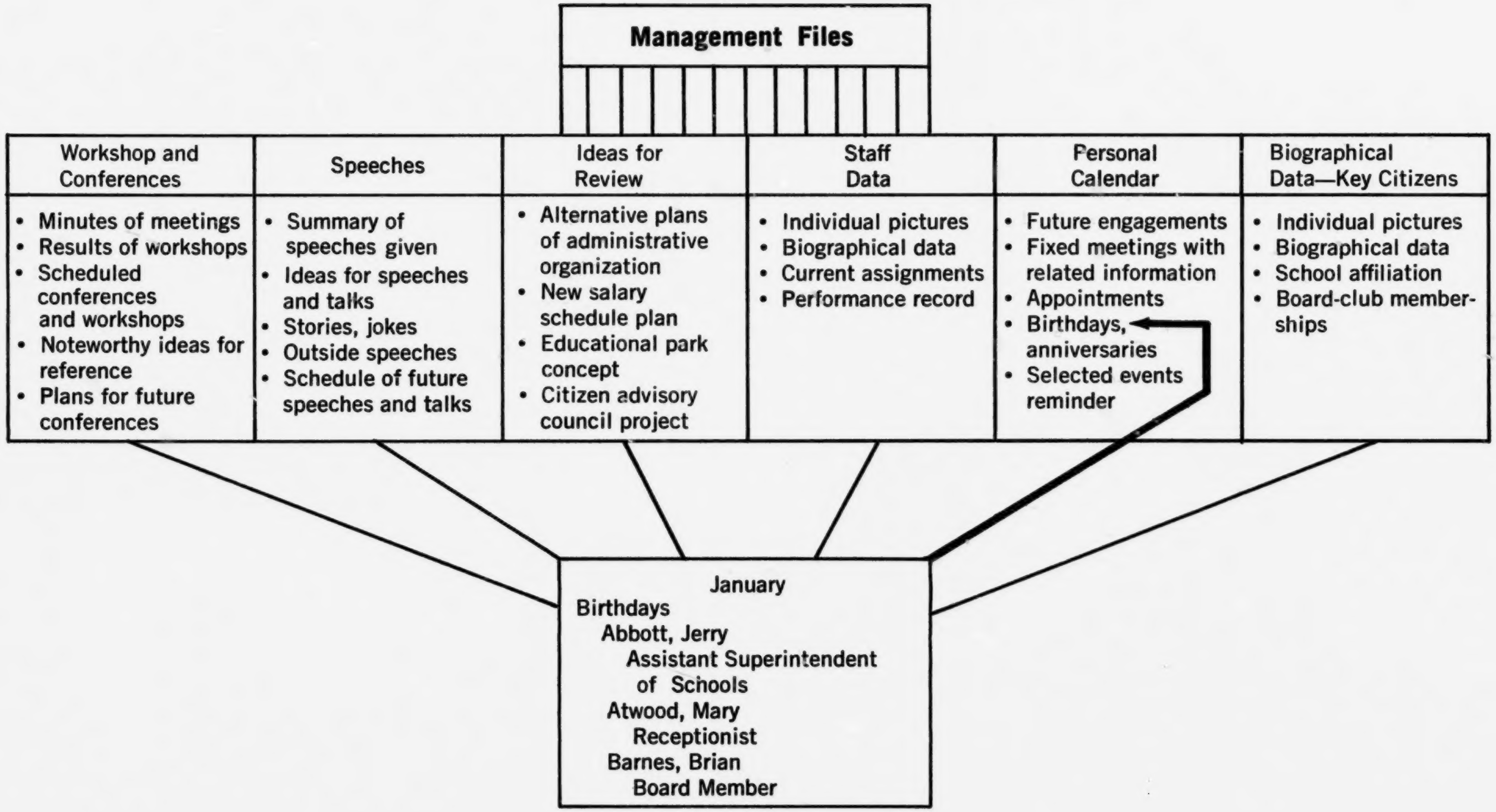
The job of separating the useful information from the useless, and then deciding what to do with it, is not a simple one for the superintendent. Many items of information will be recognized as having value for reference at some future date. Conventional filing systems have a way of storing information and concealing it from the attention of the executive. This limits his effectiveness, for the typical administrator, however capable he might be, is afflicted with a poor memory. What is needed is a new filing system which can accommodate the great input of valuable information and provide its ready disclosure whenever necessary.

Current developments in computer technology indicate that such filing systems are already available through the use of computers or data recorder and storage devices. This new partnership between manager and machine promises to usher in a new era which will extend the capabilities of the executive by jogging his memory and making his stored information more usable.

Consider how a particular data recorder and storage device (which has already been built and is in use) might be utilized to improve executive performance. This machine photographs data from an 8½″ x 11″ paper onto a 16mm film. The information is then stored in small capsules for quick recall. By pushing a button the desired file can be projected onto a screen for viewing. The machine can store hundreds of thousands of slides providing a management file system of tremendous capacity. Chart III illustrates how a school superintendent might organize several personal management files for his own use. This superintendent has developed files containing information on workshop and conference results, speeches, ideas for review, the professional staff, his personal calendar, and key citizens in the community.

These files would not be unlike those which might be developed in folders and stored in conventional file cabinets. The difference lies in their accessibility. Once a month, for example, the administrator might set aside an hour or two for file browsing. This could be done with a minimum of effort merely by selecting files and viewing the screen as information is visually presented for examination. In the chart the superintendent has activated the birthday file for January and has been reminded that among others who have birthdays in this month are his assistant superintendent and a board

Chart III



Management Files

Workshop and Conferences	Speeches	Ideas for Review	Staff Data	Personal Calendar	Biographical Data—Key Citizens
• Minutes of meetings • Results of workshops • Scheduled conferences and workshops • Noteworthy ideas for reference • Plans for future conferences	• Summary of speeches given • Ideas for speeches and talks • Stories, jokes • Outside speeches • Schedule of future speeches and talks	• Alternative plans of administrative organization • New salary schedule plan • Educational park concept • Citizen advisory council project	• Individual pictures • Biographical data • Current assignments • Performance record	• Future engagements • Fixed meetings with related information • Appointments • Birthdays, anniversaries • Selected events reminder	• Individual pictures • Biographical data • School affiliation • Board-club memberships

January
Birthdays
Abbott, Jerry
Assistant Superintendent of Schools
Atwood, Mary
Receptionist
Barnes, Brian
Board Member

member. While this may not meet the definition of management information, it certainly provides information which can be helpful in maintaining the good personal relations which are important to effective management.

The new management information filing systems will eliminate much frustration caused by today's personal filing systems and promise to expand the administrator's ability to make use of helpful data. By their tremendous storage capacities and information retrieval capabilities, the new equipment promises to tap the unrealized potential of the file system for the improvement of management.

ADMINISTRATION OF THE MANAGEMENT INFORMATION SYSTEM

The responsibility for the administration and control of the management information system must be determined if this technology is to have maximum value. Computer professionals with little or no administrative experience should not be given sole responsibility over a technology as important as the management information system. First- or second-echelon administrators should be responsible directly for the systems and data-processing work. Top school administrators must take a long hard look at the technology related to the computer and its basic information systems if the potential that resides therein is to be achieved.

SUMMARY

The advent of third-generation computers and improved peripheral equipment has materially advanced the art of management information reporting. It has enabled the development of an administrative information technology. New systems which are using data contained in the organization's basic information system and adapting it to the particular needs of management are commonplace and are helping administrators to discharge their functions more effectively. Still in the experimental stages are management information systems which permit the administrator to communicate directly with the computer and receive information instantaneously and in varied forms. There is little doubt that the next 10 years will bring dramatic changes in ways in which the computers supply information to management. Indeed, today's concept of administrative information systems may be extended beyond present limits by tomorrow's developments. The evolvement of management information systems through careful planning and adaptation of sophisticated equipment provided the data base for the systems technology.

CHAPTER 4

PPBS, A Resource Allocation Decision System

Organizations pursuing objectives require resources to initiate and sustain purposeful activity, and schools are no exception. The more complex the institution, the more imperative it becomes to develop a plan which will identify human, financial, and material resources necessary and/or available to pursue varied missions. Budgeting can be thought of as a process which describes what goals will be accomplished rather than simply as a record of things and services to be permitted next year. The budget document is viewed within the decision-making technology as an instrument which helps relate objectives to resources required to maximize achievement of the objectives. This is a relatively new concept of the budget. Budgeting itself is a twentieth-century development in education. One of the significant contributions of the professionally prepared school superintendents in the 1920's and 1930's was the introduction and design of the budget as an important fiscal planning and control instrument in school operations.

The emerging administrative technology contributes to the smoother operation of budget development and control. Through computer-based electronic data processing, the budget and other fiscal information can be maintained, updated, analyzed, and retrieved with greater ease than ever before. It must be emphasized, however, that this latter advantage is secondary to the new role and importance attached to the budget in the modern decision-making process.

Budgeting in General

A budget is one way of expressing a set of purposes translated into a plan of action for a stated period of time. It is by nature future-oriented. The importance of this fiscal instrument was recognized around the end of the nineteenth century by Prime Minister Gladstone of Britain when he declared: "Budgets are not merely matters of arithmetic, but in a thousand ways go to the root of prosperity of individuals, and relations of classes, and the strength of kingdoms." The maxim "expenditure depends on policy" can be traced to Gladstone's days.

The early focus in budgeting was on resources needed to perform specific functions rather than on resources required to achieve objectives. This gave rise to the so-called functional character classification for school expenditures of the late 1920's. This classification scheme has dictated the school budget format up to the present time. Expenditures were planned for a relatively short fiscal period, such as one year, and were organized in terms of such school activities as instruction, administration, plant operation, and maintenance. The system of grouping expenditures placed emphasis on means; administration, plant operation, and maintenance were not ends in themselves. It was believed almost implicitly that certain activities always produce certain results. This made things more comfortable, for it was easier to measure how much was spent on (or put into) a function, such as instruction, than it was to determine how much was learned as a result of certain inputs.

When new educational responsibilities emerged, separate functional classifications were created within the school budget. Thus, after World War II, attendance services, food services, transportation, and community services appeared as relatively new budgetary classifications. Again, it should be evident that outputs of the educational organization were implied but not stated in the budget document. Nor were there any hard data on the degrees to which an objective was to be realized through expenditure of resources.

Budgeting and Decision Making

More often than not, the cycle of events related to budgeting was conceived primarily in mechanical and fiscal terms, that is, on a fairly close matching of receipts and expenditures for a given year. Often there was an underlying hope for a surplus at the end of the relatively short fiscal planning period. It was not unusual for budget planners to overstate expenditures and understate receipts. It was the unusual budget document which contained educational justifications for any changes in expenditure requests. Educational goals were related only indirectly to utilization of resources. More often, past practices were perpetuated with minor modifications. The typical procedure was to record expenditures for a given budget classification for one or two previous years, enter the request for the future year, and note additional amounts requested. Little effort was directed toward justification of increases on grounds other than vague allusions to "need." The relationship between gains in effectiveness in performing a function or fulfilling an educational goal and additional sums requested was overlooked almost completely.

The new decision technology based on systems and the consequent revision of budgeting practices were stimulated toward fuller development by the unprecedented growth in expenditures in business, industry, and government, as well as education. Resources were becoming scarcer; this in turn prompted growing concern for optimizing human, fiscal, and material resources. How to do this, how to decide on the division of scarce dollars among competing educational programs was a challenge of prodigious proportions. It was at this point that many began to recognize that traditional approaches to budgeting did not shed much insight into the problem. Something new was demanded to meet this challenge. Not all of the blame could be laid at the doorstep of the budgeting process, however. It is a fact that educational goals are not easy to translate into operational terms. Furthermore, there is a paucity of indicators and simple measures for the end products of something as complex as human learning, which takes place over at least 12 years, the assigned period of responsibility for schools. In short, a fiscal instrument such as the budget cannot by itself solve the resource allocation problems, though the manner in which fiscal data are presented in a budget document may shed light on expenditure patterns for certain purposes. As will be demonstrated subsequently, something more than an approach to organizing information in a budget is necessary in the total decision system. Nonetheless, the important determination of whether a unit increase in resources allocated to a given purpose will result in some measurable improvement in the given mission is all but impossible in traditional budget formats.

In all fairness, it must be stated that the budget document we have known in past years was not designed to be anything more than a disciplined way to handle expenditures.

Its chief concerns were accuracy and control, and it served these purposes well. In PPBS, as will be shown later, the budget takes on new significance. Its control function becomes muted; greater significance is attached to it as a planning device, that is, as a source of data basic to analysis necessary to determine the most prudent course of action.

Clearly, the complexity of educational operations, the scarcity of resources available for educational programs, and the growing public demand for evidence of what results could be expected from increased fiscal inputs called for new planning, analyzing, and evaluating approaches. The technology known popularly as the planning-programming-budgeting-system (PPBS) and sometimes as program budgeting was developed to better relate inputs to outputs, that is, resources to objectives. By so doing it may facilitate decision making on how to distribute staff, money, facilities, and equipment to sometimes competing educational purposes. PPBS is not a new machine or piece of hardware. It is an intellectual technology and is part of the systems approach to administration.

By the end of the 1960's, there was evidence of considerable interest in applying PPBS to school operation. A growing number of management consultant firms, special divisions of selected industries, and special projects funded by the U.S. Office of Education demonstrated an interest in studying the problems of adapting PPBS to education. Some school districts claim to be using program budgeting at this writing, but few of these can meet the tests of PPBS suggested here.

Budgeting in education has failed to match the strides of business, industry, and government. To date there has been more talk about PPBS (although this is encouraging) than there has been implementation. Financial and accounting manuals issued by the U.S. Office of Education do not as yet reflect a shift to classification systems and analysis which are related to PPBS. There is evidence of considerable interest on the part of leaders in the U.S. Office of Education to develop approaches and procedures consistent with the demands of program budgeting. The AASA Commission on Administrative Technology commends the positive interest and research grants that may lay a sound foundation for the development and dissemination of PPBS in education.

Dimensions of PPBS

There are various conceptions of PPBS. To some it is a fiscal tool, whereas others view it in broader terms and equate it with systems analysis. The word "budgeting" within PPBS may suggest that this new technology is little more than a fiscal device, that is. one of the instruments essential for effective financial administration. It cannot be emphasized too strongly that more than budgeting is involved. No PPBS can be designed, implemented, and utilized effectively by the school fiscal officer acting alone! PPBS is a sophisticated approach requiring the efforts and insights of all administrative echelons in a school system. The emphasis should be on the last word, "system," to suggest that the three processes that precede it are interrelated. The acronym PPBS is incomplete, as will be shown later, and does not imply processes that follow budgeting.

There are four major dimensions to PPBS. It can be perceived in terms of structure, namely, as a particular kind of classification for budget items, exhibit arrangements, or report formats. The programmatic or output-oriented categorization of school budgetary accounts is part of the structural dimension of PPBS.

The second important aspect is generation and analysis of alternative courses of action. The strategy behind arranging fiscal data in a program format is to facilitate the analyzing of alternative courses of action available to an organization pursuing varied objectives. The entire store of quantitative and nonquantitative analytical tools consistent with systems becomes part of PPBS as well. The often overlooked analysis dimension is most crucial. There can be no PPBS unless some staff members possess analytic capabilities. In other words, a program format for budgetary accounts is not an end in itself. The same can be said for the analysis, however sophisticated it may be.

Facilitation of prudent decision making is the third and perhaps most important dimension. Structure and analysis are related to decision-making activity. PPBS is a decision technology—a way to present organized information, a definition of alternative courses of action, and an analysis of choices to select the most prudent. It does not lessen the pain or difficulty of making judgments. PPBS can contribute best to those decisions which focus on allocation of resources among competing purposes. This suggests that the technology is better labeled a "resource allocation decision system" (RADS) than the now popular PPBS. This new terminology is based on purpose or output rather than on processes or procedures involved. A label related to the end product is more consistent with systems thinking than one which is based on some of the processes involved (e.g., the processes of planning, programming, and budgeting). Another reason why the term "PPBS" is less desirable than "RADS" is that it can create confusion due to an incomplete identification of functions performed in the total process. To illustrate, the important processes of analysis and evaluation are not included in the PPBS acronym.

The fourth dimension is time. Complex goals are not likely to be achieved within a single year. The multi-year planning and programming activity is an important characteristic of PPBS.

A reverse ordering is suggested to better depict priorities in the multidimensional nature of the PPBS or RADS. The prime function is prudent decision making over time and at top-echelon levels. This implies that the superintendent, the school board, and the first-echelon administrative levels are all involved. Second, since decision making is based upon information and careful analysis of alternatives, sufficient staff strength and systems capability are required to make it operative. In other words, an inadequately or inappropriately staffed administrative division would have small chance of implementing successfully PPBS or RADS. Finally, resources must be related to objectives in a programmatic fashion to facilitate explicit consideration of the pursuit of policy objectives.

Every major organization with any degree of complexity finds it necessary to make certain compromises in selecting or ordering objectives. Which ones deserve high priority and which ones should be modified must be determined. One function of budgeting that is implemented through the common denominator of money is to help determine which are the most prudent compromises. Programmatic classification enhances the utilization of the budget as a vehicle in deciding how to allocate scarce resources among competing objectives. As will be described more completely later, neither the acronym PPBS nor the term "program budgeting" describes accurately the substance of the system.

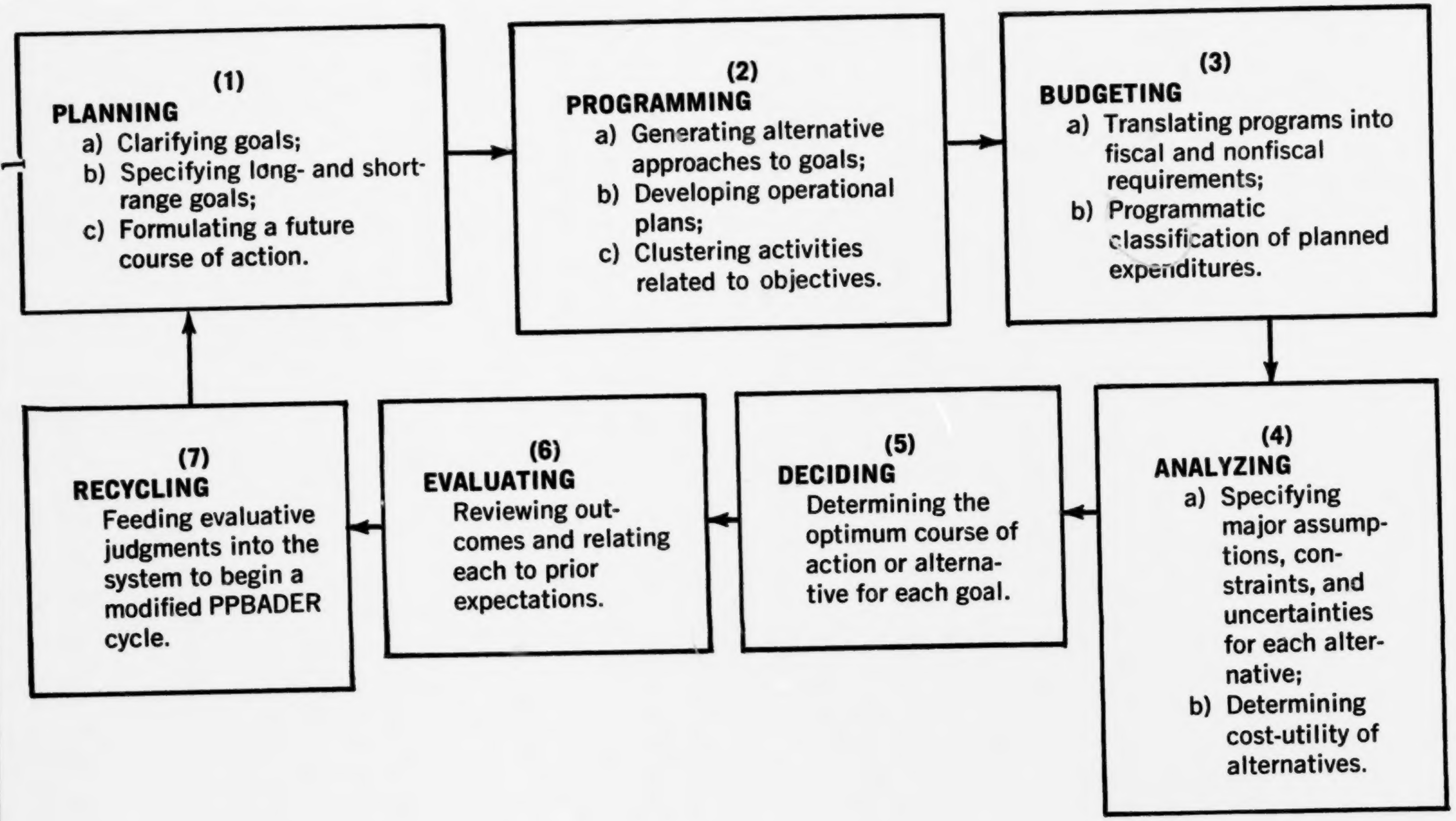
A Brief History

Although "RADS" is more precise and more consistent with the systems approach, "PPBS" is far more popular and most of the literature to date uses that term. Reluctantly, it will prevail in this writing as well even though incomplete and even though process focused. PPBS, as the last letter infers, is a system. The letters imply only three interrelated activities, or at least the three most important activities, namely, planning, programming, and budgeting. The contributions of PPBS go far beyond these processes, however, and its major significance lies in the manner in which the technology helps decision makers determine which policies should be adopted. Its basic rationale is that the most prudent policy is that which is likely to contribute most toward the goals of an institution and can do so within the constraints of most efficient use of resources.

The crucial step of systematic analysis and the culminating activity of evaluation are unfortunately omitted from the acronym. A more accurate one would be PPBAES. The complete system incorporates planning, programming of plans, budgeting in a programmatic fashion, analyzing in a systematic fashion the fiscal and program plans, and, finally, evaluating. The act of deciding could be involved as could be the process of re-cycling. This would suggest the longer acronym of PPBADERS as the most comprehensive indicator of all processes involved. Note the diagram showing the cycle of PPBADERS activities.

As described more completely in Chapter 2, PPBS got its start in the federal government. It was introduced in the Department of Defense (DOD) in 1961 to improve the planning function, which was judged to be in disarray because it was not as realistic as necessary, lacked criteria upon which to render judgments in making difficult choices, and was poorly linked to fiscal implications of the decisions.[1] The criticism was not that there was an absence of planning, but that the kind of planning then current failed to generate information and interpretations essential to prudent decision making, particularly on a long-range basis. To illustrate, substantive planning—called military planning in the Defense Department—concerned with ultimate and intermediate objectives was divorced from fiscal planning and more often than not lacked the long-range view.

The PPBADERS (PPBS) Cycle of Activities



(1)
PLANNING
- a) Clarifying goals;
- b) Specifying long- and short-range goals;
- c) Formulating a future course of action.

(2)
PROGRAMMING
- a) Generating alternative approaches to goals;
- b) Developing operational plans;
- c) Clustering activities related to objectives.

(3)
BUDGETING
- a) Translating programs into fiscal and nonfiscal requirements;
- b) Programmatic classification of planned expenditures.

(4)
ANALYZING
- a) Specifying major assumptions, constraints, and uncertainties for each alternative;
- b) Determining cost-utility of alternatives.

(5)
DECIDING
Determining the optimum course of action or alternative for each goal.

(6)
EVALUATING
Reviewing outcomes and relating each to prior expectations.

(7)
RECYCLING
Feeding evaluative judgments into the system to begin a modified PPBADER cycle.

Planning is a means of coping with uncertainty. Its focus is on future events. It is concerned with the attainment of a hierarchy of objectives within certain time constraints and available resources. Through the planning process goals are clarified and priorities are specified. It is the continuous activity of relating organizational activities to goals.

The term "programming" is used in the noncomputer sense. It is a further refinement of planning. The accepted plans are translated into more specific functions or series of output-oriented activities. It might help to think of it in terms of the verb "to program," that is, clustering operations aimed at serving the same broad mission within the institution. Programs in this sense are time-phased plans and include relating resources to stated objectives. Program categories are activities grouped on the basis of the objectives served. Program subcategories are breakdowns on the basis of more detailed or refined objectives. Program elements are specific products, goods, and services, combined with personnel, equipment, facilities, and other services organized to fulfill or support program activities. Educational activities must be reorganized to exhibit a program structure if PPBS is to prevail.

In education there is more of a tendency to use "program" as a noun than as a verb. Furthermore a program in education can refer to a group of subjects with similar substantive content or activities supported by a specific source of revenues. Neither of these definitions is consistent with "program" in the PPBS sense of the word.

Multi-Year Planning

The realization of a program objective may require many years. Multi-year program planning, with designations of how much can be achieved in any given time period, is essential in the system. In short, the resource allocation decisions are carried as future commitments as well. It is obvious that a program cost estimate extended four years beyond the present cannot be as precise or developed in as much meaningful detail as that specified for the next fiscal year. A high degree of specificity is not required in long-term program planning. Nor should it be assumed that the estimate made now of a program cost five years hence must never be changed during the interim. On the contrary, estimates are revised as soon as new data become available, and this continues until the future fiscal period is reached. By looking many years ahead, the administrator gains a better perspective on total commitments for a program.

Budgeting, the last function in the popular acronym, should not be divorced from the first two activities of PPBS. It is the element that makes planning more realistic than specification of program categories alone. Budgeting brings fiscal resources demanded in planning and programming into sharper focus.

It bears repeating that programs are described by their output and not simply by the process involved or inputs. Budgeting classifications and exhibits, therefore, must be organized in forms of output or missions-to-be-accomplished categories. This is a fundamental modification of the typical procedure based on classification according to input categories or objects such as numbers of personnel employed; expenditures for operations and maintenance; cost of research and development; or amount spent on construction. Federal government budgets in years past used headings such as personnel or materials and supplies, but schools did not consider these objects as a basis for major accounting classification. Educational accounting classification systems reflected much broader activities or functions. The switch to a program format in education, therefore, should be accomplished with greater ease since established practices in education are closer to approaches recommended in PPBS.

The most difficult problem likely to be encountered in implementing PPBS in education is the translation of the often vague and general statements of educational objectives into operational terms. Defining with clarity what constitutes an "educated" or "productive" person is a major task. Defining, obtaining agreement on priorities, and measuring educational outputs represent complex challenges. This explains in part why allocation of resources to specific functions has been preferred. Persons unacquainted with the nature of learning and varied missions of the school have tended to oversimplify the problems and issues in adapting PPBS to education. Generalizing from the limited and comparatively simple aspects of business may distort the nature of the problems likely to be encountered in education. Failing to assess accurately the full dimensions of the problem may give rise to a false sense of euphoria and subsequently dashed hopes when too much is expected too soon.

The programmatic plan covers the time span similar to that for the fiscal plan and must be based on similar terminology. Exhibits in budget documents are designed to facilitate identification of fundamental objectives in programs. Relevant information is presented in a format that will make generation of alternatives and their cost-utility analysis simpler. Only then can the budget be described as the financial interpretation of a program plan.

Analysis and PPBS

Analysis is so crucial to the implementation of PPBS that it deserves to be highlighted. As a matter of fact, the full potential of PPBS cannot be realized without it. Much of the present discussion of PPBS in education must be judged pedestrian because of the almost total failure to consider the importance of quantitative and nonquantitative analysis in conjunction with it. The PPBS movement at this writing is preoccupied with the initial phase of developing a new taxonomy for expenditures. Unless and until reclassification of fiscal transactions are related to objectives and this relationship is subjected to analysis, PPBS will be of little value in enhancing the decision-making skills of administrators. Thus a programmatic classification alone is not likely to resolve the dilemma of whether to allocate an additional $100,000 to an expansion of counseling services, to the employment of more paraprofessionals, or to the reduction of class size. The final choice may be determined by pure chance, political pressure, guesswork, intuition, or the recommendation of an alleged authority rather than rational analysis. It is assumed that if PPBS is used the act of deciding will include systematic, objective, or scientific analysis. In a sense, planning, programming, and budgeting are merely the preliminaries that make the analysis more accurate, valid, and defensible.

Analysis is rooted in the scientific approach to attacking problems. It is derived from the steps outlined by John Dewey in his classic *How We Think,* written at the turn of this century. As stated in Chapter 2 the new decision technology is as old as the development of the scientific approach to problem solving, but as new as the sophisticated quantitative analysis techniques, many of which never existed when Dewey lived. More will be said later about mathematical models used in this rational analysis.

A key factor in the evaluation of a set of alternatives is the relation between cost of each and the benefits derived from each. Total cost includes direct and indirect expenditures and also tangible and intangible sacrifices. Analysis can degenerate into an empty, albeit a popular, ritual where it probes a single approach to the fulfillment of a mission and ignores all others. A decision is a choice between two or more options; therefore an analysis must be based on comparing two or more approaches related to a given decision situation. The failure to generate two or more rational options precludes the free play of the decision technology called systems. An illustration of options is in order. Assume that an educational goal is to reduce high school dropouts to a given number or percent and that resources in the amount of $500,000 are allocated to do so. To reach the goal of fewer high school dropouts the money can be used to design and operate a work-experience program for the dropout prone; reduce the class size in all subjects for the dropout prone from 30 to 20; hire a given number of paraprofessionals to assist teachers assigned to such groups; employ social case workers to work with the families of the dropout prone; or purchase special learning equipment such as computer-assisted instruction for potential dropouts. With alternatives specified, analysis is employed to determine which action, or combination of actions, is most likely to yield optimum results, that is, make use of the $500,000 so as to maximize the numbers continuing in school, have the greatest impact on the community, and the like. Certain constraints placed upon utilization of resources, such as precluding school expenditures for the employment of social case workers, may limit attainment of the optimum. In the absence of hard data the analysts may be forced to render judgments on how many paraprofessionals are needed to reduce likely dropouts by 10 or 100 pupils. The more limited the data base, the less the reliability of the judgments based on the analysis.

Testing reality, that is, evaluating whether the objective analysis was accurate and a given level of effectiveness was attained for a specific measure of resources, is the final step in the system. It calls for a hard look at the results rather than simply an examination of the hoped-for achievements in evaluation. The results are compared with prior expectations.

Hatry and Cotton defined PPBS, enumerated its limitations, and described the difficult steps in conducting analysis as part of the total PPBS.[2] Through PPBS the administration may receive systematic information on costs in relation to the benefits of alternative ways of reaching a given objective. It is not all-powerful. There are many things which cannot be done, nor should they be expected. PPBS adds little to implementation of the adopted budget, to manpower selection, to assessment of work efficiency of operating units, or to cost control of current operations. The cost accounting and nonfiscal performance reporting systems provide the data basic to the analysis phase of PPBS. PPBS should not be confused with efforts to reduce public spending. The system is basically neutral on the issue of cost reduction. It is concerned more with optimizing returns on expenditures, and this could lead to switching resources from one less productive to another more productive program.

Two levels of analysis can be distinguished by the depth, time, or rigor spent in pursuing various dimensions. Less rigorous analysis is likely to be, at least initially, more prevalent in education. A decision based on analysis of alternatives for the allocation of resources moves ahead by identifying and documenting the following: [3] the real objectives of the program, major feasible alternatives, best available estimate of the total program cost for each year considered for each alternative, best available estimate of benefits relevant to objectives for each alternative, major assumptions and uncertainties associated with the alternatives, and impact of proposed programs on government agencies or on private organizations.

In-depth analysis, as the title implies, goes further and approaches what are called cost-benefit or cost-utility studies. Some writers confine in-depth analysis to those situations where key factors can be quantified and mathematical models can be generated. Significant nonquantifiable program elements are not ignored but are granted less weighting. In-depth analysis often takes many weeks to effect even in the well-staffed organization. Sufficient lead time must be available. The amount of time and money required suggests that in-depth analysis cannot be used indiscriminately. Priorities must be established to select those programs with the highest likely payoff.

It may take local school systems many years to identify and then support a team of specialists capable of conducting in-depth analysis. Among the severe limitations on pursuing meaningful in-depth cost-benefit analysis in public education, as well as in government, are problems of agreement on operationally defined and real objectives, the fact of multiple and incommensurable benefits, the difficulty in obtaining accurate data pertinent to analysis, and problems encountered in looking at costs and benefits over a time span rather than as a single point in time.[4] Nonetheless, whatever the difficulties, a significant outcome of the analysis process is the generation of new alternatives for pursuing a goal.

Organizational Implications of PPBS

PPBS will have an impact on the way the organization is structured. Questions often raised when serious consideration is given to implementing PPBS in educational institutions[5] include:

1. Should direction of the PPBS be assigned to a specially created "central (systems) office," an adjunct of the central budget office, or some other existing administrative unit? Selecting missions, organizing an information system, systematic analysis, and rational decisions go beyond simply budgetary or other fiscal considerations. This suggests that the central analysis staff is better organized as a separate department reporting to the chief administrator or as an agency attached to the chief administrator's office.

2. What kinds of personnel are needed to fulfill PPBS responsibilities? There can be no meaningful analysis without personnel qualified with technical skills and understanding of at least mathematics and economics. The size of the full-time staff will depend upon the magnitude and complexity of the governmental unit. PPBS cannot have a significant impact on any educational organization without additions to the existing administrative staff.

3. Must there be a drastic reorganization of administrative levels to accommodate PPBS? PPBS alone may not be the compelling reason for such decisions. Experience in the federal government points out that no agency's structure has been altered significantly as a result of adopting PPBS.

There are other factors which deserve consideration, such as the likely sources of opposition to the introduction of PPBS in a school, likely changes in existing accounting procedures, the speed of implementation, and so on. Some points to remember about these issues are:

1. More than likely opposition will come from persons accustomed to behaving in a manner inconsistent with the basic tenets of PPBS.

2. PPBS encourages movement toward establishing an objective-oriented program budget. It will affect accounting classifications. In accounting, however, details such as noting the object class will still be required It is the way the objects of expenditures are grouped in subheadings to attain the purposes of PPBS that will be different.

3. Cooperation between the school board and the administration is necessary to institute PPBS. This is true even though PPBS is regarded as being primarily an internal management tool.

4. During early efforts to incorporate the system, it may be more realistic to try PPBS on selected programs in edu cation rather than to implement it across-the-board. This

gradual or partial implementation strategy may be more realistic than others in view of the staffing difficulties likely to be encountered.

5. The speed with which PPBS can be developed depends in part on the backing of the chief executive, the funds available, and the quality of the staff.

6. There are political constraints on program analysis which must be considered in instituting PPBS.

7. PPBS cannot be implemented without an extensive data bank on costs, planning factors, and evaluation of benefits. Electronic data processing is a useful tool to facilitate data processing related to analysis and in presentation of models, activities, and reports.

8. PPBS can be misused, particularly when poor data are available, data are incorrectly used, or data are purposely manipulated to achieve nonscientific purposes. PPBS is not an end in itself. There is a danger that it may be focused on too many decisions or on minor issues.

9. PPBS is primarily a high-level decision-making tool and will not be worthwhile unless the persons on this level understand it, want it, and use it. The notion that a single specialist in the hierarchy, rather than the generalist at the top level, should assume dominant direction of an approach as fundamental as PPBS is inconsistent with systems theory. Interrelationship among key executives, that is, the team or task force attack, is basic to systems.

Expenditures and Objectives

Organizing expenditures in terms of program objectives has been recommended for many years. In education there has been a tendency to relate expenditures to broad educational functions, such as instruction, rather than to objects. With PPBS, however, the functional character classification "instruction" is much too broad and not related closely enough to output categories. Nor would it be appropriate to state simply how much is allocated to, say, mathematical instruction. The level of mathematical skills gained per unit of initial or additional resource allocation becomes a matter of prime importance. PPBS differs from the usual unit cost analysis and from the alleged scientific management or efficiency approach which attempts to determine what to teach on the basis of what costs less. This is not the purpose of the incremental cost-analysis approach in PPBS.

The fundamental idea behind PPBS is to determine what additional degree of effectiveness can be gained in achieving a given goal through a unit increase in resources allocated to the program. It is similar to the marginal analysis concept in economics. Instruction of pupils at a given level of effectiveness in mathematical computational skills, foreign languages, conversational skills, or skills in applying the scientific process or concepts to problems would be some of the program subcategories in the budget following PPBS concepts. Remedial instruction would be presented in terms of specific outputs, such as various levels of improvement in reading skills of pupils who participate, for a given allocation of X dollars, Y amount of space, and Z amount of equipment. Thus, money and outcome levels are related, and additional resource units are allocated in terms of optimizing either educational, social, or political objectives. When principals ask for more teachers, more money for supplies, more instructional space, or better plant maintenance, the requests are accepted or rejected on the probability that additional inputs will yield measurable additional outputs of pupil achievement, professional morale, or community support. This is not to imply that PPBS has value only when additional sums are available. The same type of reasoning can apply in shifting resources from one program to another. It could lead to new organizational arrangements as well.

It is easy to use the terminology of PPBS, such as "program," to project the image of utilizing the system. The transition from general discussion of the importance of stating objectives, the need for programmatic classification schemes, the value of multi-year planning, and the power of cost-benefit analysis to an actual operational plan in a school district is a challenge of great magnitude. Few, if any, have been able to bridge effectively the gap between desire and fulfillment. Illustrations in the literature of alleged objective-based programs are neither mission-oriented nor closely related to PPBS. For example, classifying expenditures on the basis of subject matter titles such as mathematics, social studies, reading, science, and language arts is related only in a very general way to PPBS and is a long way from the nub of the issues. What educators call the "reading program" is not a program, much less an objective-based program as implied in PPBS. About all that some alleged program budgeting applications in education can hope to achieve is to retrieve more easily fiscal data on unit costs for inputs dedicated to reading instruction, social studies instruction, and so on. Little light is shed on the more fundamental issues of how much more must be allocated to reading if 90 percent of those reading below grade level are to be brought up to grade norms, assuming this is a desirable objective. More will be said in a later section about program formats in education.

A dynamic relationship exists among planning, programming, budgeting, analyzing, and evaluating. The focus should be on the total configuration of activities and not simply on something as familiar as budgeting. In the context of this chapter PPBS is more than a simple fiscal device; it is a way to improve decision making with respect to resource allocation.

PPBS Is Not Without Its Critics

PPBS did not win acceptance from all personnel in the Department of Defense and other departments of the U.S. government. It took time to design and even more time to gain some degree of operational effectiveness. In the spring of 1968, former Secretary of Defense Robert McNamara concluded his budget request to Congress with the following:

> One of the first things we had to do in 1961 was to design a new mechanism which provides this information [on choices of major military forces and weapon systems needed to carry out tasks and missions related to national security objectives] in the form desired, and to integrate it into a single coherent management system. The product of this effort was the Planning Programming Budgeting System (PPBS), which is now being applied widely throughout the U.S. Government and which is being introduced in foreign governments as well.

He declared that "PPBS has allowed us [the Department of Defense] to achieve a true unification of effort within the department without having to undergo a drastic upheaval of the entire organizational structure." In his view, PPBS was a mechanism to create a balance between inputs, such as finances, weapons, programs, force requirements, and strategy, and outputs, such as foreign policy objectives. It provided the entire defense establishment with the basis of a unified plan of operation.

An editorial in the April 1968 issue of *Armed Forces Management*[6] listed some exceptions to the enthusiasm and mystique surrounding this management approach. The source of dissent was the U.S. Senate Subcommittee on National Security and International Operations, chaired by Senator Henry Jackson. This Subcommittee considered the PPBS to be a special name applied by the Department of Defense to a dilemma that "is as old as the problem of the buyer who would like to make two purchases and has money for only one." Many benefits were overplayed according to the critics. The Subcommittee rejected the suggestion that the system could work miracles in all aspects of government. It discarded the notion that PPBS was a kind of "statistical litmus paper that could scientifically sort good projects from bad." Furthermore it was not a substitute for experience and judgment, though men of experience and judgment might find it helpful.

Many believe that implementation of PPBS was perhaps the most significant and lasting of McNamara's contributions. There were others in DOD who concurred with the Jackson Subcommittee that PPBS had very significant and stringent limitations. The testimony of Thomas Schelling, a Harvard University professor, before the Jackson Subcommittee supported these critics: "There is genuine concern that PPBS and other techniques of management that are essentially budgetary or quantitative, may be not only of less positive value when applied to foreign affairs but even through their tendency to distort criteria and to elevate particular kinds of analytical competence to be of positive harm."[7] Of no less significance was Schelling's opinion that PPBS was used in DOD for more than simply reducing waste or improving efficiency. He suggested that Secretary McNamara "took advantage of his central role in the defense-budgeting process to exercise what he believed to be his authority over military policy." In other words, control of the purse strings became a management technique and a source of authority. "Control of budgetary requests and disbursements is a powerful source of more general control." Furthermore, "Anything that makes budgeting more effective will add to the authority of those involved in budgeting." This is exemplified by the fact that "Budgetary procedures provide invaluable opportunities for holding hearings, demanding justifications, spot-checking the quality of planning, identifying objectives, and even enhancing competition among lethargic subgroups." But "few of even PPBS's strongest critics contend the system should be wiped away. What they do insist, with considerable substantiating argument to support them, is that the systems' limited effectiveness means it must be used not promiscuously but with considerable discretion."[8]

PPBS does fairly well in assessing the cost side of the cost-effectiveness equation. It does less well in measuring effectiveness. The task of evaluating the effectiveness of an education alternative is a prodigious challenge. In general, PPBS may improve decision making by changing it from a matter of pure visceral judgment to a more scientific procedure. Critics of PPBS point out that cost-effective analysis had its failures as well as successes. The development of the F-111 aircraft as well as the procurement and supply of adequate equipment to support the war in Southeast Asia are cited as examples. Furthermore, the critics say that PPBS has been given credit for many decisions "especially ones involving the cancellation of certain missile developments in 1961-63, which would quite likely have been made anyway."[9] The controversy that still surrounds the use of PPBS in the Department of Defense was reported fairly, even though the source magazine was addressed to the military who had to adjust to the new system introduced by a civilian secretary.

Getting Started with PPBS

At this point in time school districts in the nation lack the readiness to implement PPBS. At least four conditions must be satisfied to move into a state of readiness—a restatement of educational objectives in a program format that facilitates the use of indicators and more precise output measurement devices in education; the generation of a supply of alternatives for reaching an objective; a reclassification of budget accounts now used in individual states or recommended nationally to reflect program- and output-oriented classifications; and employment of specialized personnel with systems analysis capability. At least another decade may pass before a majority of school districts will be able to implement PPBS.

A clearer conception of PPBS is needed before getting started. Hitch pointed out that the original developers of PPBS in the Department of Defense never called it "program budgeting."[10] The term "program budgeting" was recommended by the Second Hoover Commission of 1955. For a brief period the term "performance budgeting" was more popular. Since that time, there has been some debate as to whether program budgeting is the same as PPBS or a subset within the system.

McKean and Ashen[11] identified four major dimensions of the program budgeting concept as—

1. Restructuring budget exhibits in terms of categories that are closer to true outputs and accumulating costs in more meaningful categories.

2. Developing a budget that implies a longer-term horizon than the typical pattern, which is limited to one year.

3. Using cost-utility analysis as a logical way to measure relations between inputs and outputs, that is, to emphasize the analytical contributions of the program budgeting process.

4. Developing arrangements for enforcing allocative decisions through appropriate implementation of provisions. This is a comprehensive view of program budgeting, which makes it for all practical purposes the same as PPBS.

On the other hand, Hatry and Cotton, along with others, insist that PPBS and program budgeting are not equivalent. They would confine program budgeting to budgeting systems emphasizing categorization by programs without the explicit provision for systematic analysis and multi-year perspective of

PPBS. In this sense program budgeting becomes what the term implies, namely, the programmatic classification of expenditures or simply one phase of the total PPBS. Clearly there is some dispute among recognized authorities as to whether program budgeting is a more meaningful fiscal analysis and control device based on program classification or a more comprehensive systems approach vehicle.

Much of the current literature tends to equate program budgeting with PPBS. It is stipulated here that there is better argument to support the separation of meaning for the two terms. Both concepts are needed for description and implementation. For the purposes of this document, a more limited conceptualization of program budgeting is accepted, that is, the program-oriented categorization of budgets. Program budgeting, then, deals with restructuring budget presentations to reveal outputs as well as inputs and attempts to better relate each to objectives. PPBS is the broader term and better titled RADS, or resource allocation decision system.

Clarification of the Term "Program"

The word "program" accounts for part of the difficulty in comprehending the nature of PPBS. It has many interpretations which should be explored prior to development of illustrations of applications of PPBS to education. Smithies pointed out that the terms "program," "performance," "activity," and "function" are all used more or less interchangeably.[12] "Program" is preferred in much of the literature and refers to the cluster of activities or operations related to an objective or mission. Its output-orientation and goal-seeking functions deserve to be reemphasized.

In education the term "program" has a much broader meaning and is often linked with a course of study, such as the science program or music program, and even may be confused with a set of instructions or program inserted into a computer. In some cases the term "program" may imply a series of activities supported by a special fund or grant. Thus one hears with increasing frequency of federal programs, that is, activities funded by a federal grant. In describing the school's English program or social science program, the emphasis typically is on activities related to it, or on expenditures related to it, or on expenditures related to inputs, rather than on what happens to students, that is, on outcomes. Stated another way, vocational education is much too broad to be used as the basis for resource allocation in PPBS. The development of a specific salable skill up to a specified level is a more precisely stated objective and can serve as the focus for a program in the program budgeting sense. The popular uses of the term "program" in education must be abandoned to allow a more precise determination of it in terms of outcomes or objectives if a program budgeting format is to be a meaningful part of a resource allocation decision system. Above all, program should not be based on a fund distinction, for a cluster of dedicated resources may or may not be an indicator of a program.

To program, in the program budgeting sense, is to cluster activities and related inputs around each of the many missions of an organization. This implies that the first step is to agree on educational objectives, assign priorities to each objective, and translate each into a program of action, being ready to evaluate the outcomes of such actions. This is easier said than done. Schools have multiple objectives, and each one is immensely more difficult to measure than business objectives, which are primarily to maximize profits. Industry runs into similar problems of output measurement when it desires to improve the quality of a product or strives to develop goodwill. The program format for educational institutions will become more meaningful when better indicators of progress for one or more educational purposes are developed. At present education must be satisfied with less than perfect indicators of progress toward goals.

Educational Objectives and PPBS

PPBS demands that the educational system's objectives be defined in terms of the development of specified types of learners up to stated levels of competence in narrowly or comprehensively defined concepts, skills, understandings, and appreciations. There are a number of statements of educational aims concerned with answering the basic question raised by the philosopher Spencer, namely, "What knowledge is of most worth?" Various efforts to define educational objectives have been known as the "seven cardinal principles," the four broad "educational objectives in an American democracy," and the so-called "10 Imperative Needs." These are difficult to translate into operational programs and even more difficult to measure. A taxonomy of educational objectives recognizes the cognitive, affective, and psychomotor domains. This typology suggests another approach.

For the purposes of this volume, the tasks of the schools as developed by a group of researchers at the Midwest Administration Center, University of Chicago, will provide a basis for programming education.[13] The major dimensions are as follows:

A. INTELLECTUAL DIMENSIONS

1. Possession of knowledge: Concepts: A fund of information
2. Communication of knowledge: Skills: To acquire and transmit
3. Creation of knowledge: Habits: Discrimination and imagination
4. Desire for knowledge: Values: A love for learning

B. SOCIAL DIMENSIONS

5. Man to man: Cooperation in day-to-day relations
6. Man to state: Civic rights and duties
7. Man to country: Loyalty to one's own country
8. Man to world: Later—relationships of peoples

C. PERSONAL DIMENSIONS

9. Physical: Bodily health and development
10. Emotional: Mental health and stability
11. Ethical: Moral integrity
12. Aesthetic: Cultural and leisure pursuits

D. PRODUCTIVE DIMENSIONS

13. Vocation—Selective: Information and guidance
14. Vocation—Preparative: Training and placement
15. Home and Family: Housekeeping, do-it-yourself, family life
16. Consumer: Personal buying, selling, investment

To these missions must be added those which enable the system to aid learners who do not learn as well as others and who therefore require compensatory experiences; to facilitate system development and maintenance; and to facilitate relations with the environment in which the system must operate.

An illustration of a program format based on the substance of educational experiences and the nature of clientele to be served may be outlined as follows:

Objective I: To promote educational growth and development

PROGRAM A: Experiences to continue intellectual growth—possession, communication, creation, and desire for knowledge
  Subprogram 1: For Client Service Unit P—primary units for children under five
    Program subcategory a: Developing the ability to think and communicate clearly

- Program subcategory b: Developing the desire for knowledge
- Program subcategory c: Acquiring pertinent quantitative knowledge
- Program subcategory d-n: Other specific objectives promoting intellectual growth on a regular and sequential basis
  - Program activity 1: Direct instructional services
    - Program element a: teacher salaries
    - Program element b: instructional supplies

  - Program activity 2: Special instructional services
    - Program element a: counseling salaries and other inputs
    - Program element b: psychological testing and related services

  - Program activity 3: Administrative services
    - Program element a: principal salaries, supplies, etc.
    - Program element b: supervisory salaries, supplies, etc.
    - Program element c: central office salaries, supplies, etc.

  - Program activity 4: Instructional facilities

  - Program activity 5: Innovations and pilot projects

Subprogram 2: For Client Service Unit E—elementary units for pupils in grades kindergarten through 6

(Program subcategories as above modified to relate to pupils of this level of development)

(Program activities as shown above)

(Program elements as shown above)

Subprogram 3: For Client Service Unit J—junior high or middle school units

Subprogram 4: For Client Service Unit S—senior high students

Subprogram 5: For Client Service Unit C—community college students

Subprogram 6: For Client Service Unit A—adult units

Subprogram 7: For Client Service Unit X—exceptional student units

PROGRAM B: Experiences to continue social development—man to man, man to state, man to country, and man to work

(Subprograms, program subcategories, program activities, and program elements developed similarly to those shown for Program A)

PROGRAM C: Experiences to continue personal development—physical health and development, emotional health and stability, ethical development, and aesthetic development

(Subprograms, program subcategories, program activities, and program elements developed similarly to those shown for Program A)

PROGRAM D: Experiences to continue developing the productive capabilities of individuals—vocational selection, vocation preparation, home and family life, and consumer skills and insights

(Subprograms, program subcategories, program activities, and program elements developed similarly to those shown for Program A)

Objective II: To provide compensatory experience and to ensure completion of educational opportunities

PROGRAM A: To minimize the number of students who terminate their education prematurely—dropout prevention

Subprogram 1: For pupils in elementary or middle school client service units

Program subcategory a: To identify potential dropouts

Program subcategory b: To design compensatory programs

Program subcategory c: To provide a pattern of home and family counseling

Program subcategory d: To provide job opportunities and stipends to the study

Subprogram 2: For senior high students
(Program subcategories similar to those above)

PROGRAM B: To reduce learning deficiencies among students
(Subprograms and program subcategories similar to those above)

Objective III: To maintain system support services at efficient levels and design new system approaches

PROGRAM A: Improving staff rapport and staff negotiations

PROGRAM B: Operating an efficient transportation system for clients served

PROGRAM C: Ensuring system security

PROGRAM D: Evaluating system operations and designing new approaches

PROGRAM E: Managing with efficiency the system's fiscal and material resources

Objective IV: To develop satisfactory environment relations and to sense changing social demands on the system

PROGRAM A: Improving parent and community relations

PROGRAM B: Developing more effective state and federal relations

PROGRAM C: Meeting the standards of accrediting agencies

PROGRAM D: Meeting attacks on schools

It is not imperative that the reader accept this list of important educational objectives to develop a program format for budgetary purposes. A given person, community, or state could develop an entirely different set of purposes. The important point is that inputs are clustered around some statements (rather than only one statement) or educational objectives. Policy objectives must be known and agreed upon locally, statewide, or nationwide to develop a program budgeting approach.

Indicators and Analysis: An Illustration

After objectives have been agreed upon, the next step is to develop indicators of progress, that is, measures of effectiveness in attaining goals. These may include test scores, informal appraisals, empirical data on reductions in problem situations, or others. This is perhaps one of the most difficult challenges.

The generation of alternative ways of realizing each of the objectives follows. In Objective II, Program B (reducing learning deficiencies), the alternatives were discussed in an earlier section. Analysis of reduction of learning difficulties as related to cost within legal and budgetary constraints would help in the decision as to which alternative or combination of alternatives is feasible.[14]

Program budgeting does *not* eliminate the need for recording expenditures by object. It merely gives such detailed classification information a relatively minor role in budget formats. In reality, there is less need for a drastic change in accounting if there has been careful coding and if electronic data processing is available to facilitate retrieval of data and its organization around the missions of the school.

A multi-year financial plan built around a program format would look something like the following:

Program Categories I. Educational Growth and Development	FY* 1968 Program Estimate	FY 1969 Program Estimate	FY 1970 Program Estimate	FY 1971 Program Estimate	FY 1972 Program Estimate	FY 1973 Program Estimate	Total 1968-73 Program Estimate
A. Intellectual Growth 1. Primary Client Service Centers							
2. Elementary Client Service Centers							
3. Middle School Client Service Centers							
4. Senior High Client Service Centers							
5. Community College and Adult Client Service Centers							
6. Exceptional Student Client Service Centers							
B. Social Development 1. 2. 3. 4. 5. 6.							
C. Personal Development 1. 2. 3. 4. 5. 6.							

Program Categories	FY * 1968 Program Estimate	FY 1969 Program Estimate	FY 1970 Program Estimate	FY 1971 Program Estimate	FY 1972 Program Estimate	FY 1973 Program Estimate	Total 1968-73 Program Estimate
D. Productive Development 1. 2. 3. 4. 5. 6.							
Total for all programs under I							
II. Compensatory Experiences							
A. Dropout Prevention 1. Among Elementary and Middle School Students 2. Among Senior High Students							
B. Reducing Learning Deficiencies							
Total for all programs under II							
III. System Maintenance and New Designs							
A. Staff Rapport and Negotiations							
B. Transportation							
C. System Security							
D. Evaluation of System Operations and Design							
E. Fiscal and Material Resource Management							

Program Categories	FY* 1968 Program Estimate	FY 1969 Program Estimate	FY 1970 Program Estimate	FY 1971 Program Estimate	FY 1972 Program Estimate	FY 1973 Program Estimate	Total 1968-73 Program Estimate
Total for all programs under III							
IV. Environment Relations							
A. Parent and Community Relations							
B. State and Federal Relations							
C. Accrediting Agencies							
D. Attacks on Schools							
Total for all programs under IV							
Grand total for objectives I through IV							

*Fiscal Year

SUMMARY

PPBS is part of the modern decision technology called the systems approach. It calls for the kind of classification of fiscal and other data that may enhance analysis and subsequent decision making with reference to allocation of resources to competing purposes. The title "resource allocation decision system" is a better description of what is popularly called PPBS. The letters in the acronym fail to include important parts of the process, such as analysis and evaluation. It is apparent that PPBAES casts the budget in new roles that go beyond the traditional control functions.

The prime function of PPBS is to enhance prudent decision making by top-echelon administrators. This is accomplished by generating alternatives for attaining objectives and relating resources demanded by each alternative. The analysis compares the benefits derived in relation to the costs. Some writers declare that program budgeting and PPBS are one and the same. This writer joins with others who view program budgeting as a subset of PPBS.

One of the most difficult problems likely to be encountered in implementing PPBS in education is the translation of vague objectives into more precise operational statements. Most of the programmatic classification systems for educational budgeting fall back on the traditional titles attached to curricular fields or subjects taught. These are only vaguely related to a program in the PPBS sense of the word.

Analysis is a key factor in PPBS. Special staffs with sophisticated analytical capabilities are needed to implement the system.

FOOTNOTES

[1] Hitch, Charles J. "Program Budgeting." *Datamation* 13:37-40; September 1967.

[2] George Washington University, State-Local Finances Project. *Program Planning for State, County, City*. Washington, D.C., George Washington University, 1967.

[3] *Ibid.*, p. 25.

[4] *Ibid.*, p. 27.

[5] *Ibid.*, pp. 31-35.

[6] "Is PPBS All That Good?" *Armed Forces Management* 14:32-33; April 1968.

[7] *Ibid.*

[8] *Ibid.*

[9] *Ibid.*

[10] Hitch, Charles J. *loc. cit.*

[11] Ashen, M., and McKean, R. N. "Problems, Limitations and Risks." *Program Budgeting*. (Edited by David Novick.) Washington, D.C.: Government Printing Office, 1965. p. 219.

[12] Smithies, Arthur "Conceptual Framework for Program Budgeting." *Program Budgeting, op. cit.* pp. 10-11.

[13] Downey, L. M. *The Task of Public Education*. Chicago: University of Chicago (Chicago Midwest Information Center), 1960.

[14] *Program Planning for State, County, City, op. cit.* pp. 38-69.

CHAPTER 5

Implications of Administrative Technology for Educational Staffing Patterns and Organizational Arrangements

It is evident from the data presented thus far that the rising expectations for public education generate new pressures on school administrators. Technology may help ease this somewhat, but at the price of making some fundamental modifications in the number and kinds of personnel employed and the way various administrative units are conceived and related to each other. Administrators will be expected to fulfill new roles in unique organizational arrangements. In short, new capabilities will have to be developed to meet the new expectations.

The assumption is that technology will at least liberate the superintendent from the drudgery of time-consuming routine tasks. This, in turn, will give educational leaders the added time needed to serve more effectively as change agents and as mediators of social forces that impinge upon the schools. But the power of present-day technology goes beyond relief from pedestrian responsibilities. More sophisticated utilization of the systems and computer technologies will enable the administrator to generate meaningful long-range plans, try out or simulate proposed courses of action, and develop more meaningful evaluation and control procedures.

Implementation of Technology—Some Issues and Concerns

The successful introduction of administrative technology to any school system, regardless of size, is not without costs. It will disrupt established relationships in the hierarchy, and sometimes frustrations may be generated with a temporary lowering of morale. New organizational arrangements will have to be fashioned. This takes time and money. Established organizational patterns are viewed as means to an end. Therefore, any reorganization would demand a review of goals, priorities, and critical educational issues facing the institution, as well as a review of the expectations for administrators. Technological changes will trigger a chain reaction of other changes within educational institutions.

Variables subject to the control of the school executive must be identified. The quantity and quality of resources available to the system (inputs) and the expectations and performance levels demanded by the people and/or the clients served (outputs) must be evaluated before efforts are exerted to introduce a norm for administrative technology.

The technical tools required to accomplish educational missions within the constraints and the established criteria of performance must be known as well. The agreed-upon measures of effectiveness will influence the final decisions on the organizational pattern, staff selected, and the resources allocated.

Technology involves a new way of thinking for the administrator that goes beyond the acquisition of new skills alone. It may be that the change in intellectual approaches to administration will demand new breeds of personnel as well as new machines. The new structural forms of administrative organization will be most comfortable for those capable of thinking and acting within the new environment.

Efficiency is a much prized goal, but it is an easily misinterpreted objective, difficult to measure in institutions with multiple objectives or with missions difficult to translate into operational terms. One of the major challenges confronting the superintendent is developing measures of organizational effectiveness based on reasonable and acceptable expectancy tables of performance. Another is the design of a system for monitoring operations of a system. An additional challenge is to enhance coordination of the separate elements without sapping the initiative and semiautonomy of individual school units or staff members. Without a structural form which makes the many diverse parts of the system a unity, fragmentation becomes a distinct possibility. Federal and state programs, particularly those with goals and objectives divergent from those established in a local unit, may make difficult, if not impossible, the achievement of balance and the attainment of coordination.

Effective communication is an essential ingredient in coordination as well as in other aspects of successful administration. Administrative technology that contributes to this goal often demands new approaches to operation. To illustrate, a meaningful communications system should incorporate appropriate and timely feedback to headquarters or prime monitoring substations. Feedback provides data that may trigger appropriate corrective action on the part of an administrator. It also yields information important to long-term evaluation and subsequent long-term planning. In systems thinking feedback data bridges the gap between sensing environmental conditions and making immediate or long-term administrative adjustments essential to keeping the institution locked onto its targets or missions.

Feedback to central and important decentralized decision points is an essential part of the communications system, and its importance is difficult to overestimate. This judgment is derived from the realization that administrative decisions made by the superintendent reflect personal expectations of individual behavior which may or may not be consistent with predictions derived from well-established theory. Most judgments on the effectiveness of plans and performance emanate from the superintendent or decision makers at other echelons. In view of the absence to date of appropriate theoretical foundations for decision making and the heavy reliance on intuitive judgment, we are faced with two alternatives. We can wait an indefinite time until appropriate theory is developed, or we can deal with the complicated problem of coordinating and monitoring the operation of the system by obtaining relatively sharp intuitive insights and judgments from staff and other experts concerned with the administration of the schools. The latter seems to be the most defensible alternative, despite its shortcomings.

Thus the first principle to be followed in the implementation of administrative technology is to be sure that top-echelon administrators, such as the superintendent, possess valid, recent, and accurate information on how the system as a whole is functioning in view of a new change. These readings must be made available to key decision centers both quickly and continuously. Readiness to make the necessary organizational adjustments is related to this. The success or failure of administrative technology in a given school situation will be influenced to a considerable degree by the ability, or inability, of the superintendent to develop and maintain the pulse of operations and to judge whether agreed-upon educational and administrative objectives are being pursued in an efficient manner.

DESIGNING THE ADMINISTRATIVE ORGANIZATION TO MEET THE CHALLENGES OF TECHNOLOGY

Most complex educational organizations have an administrative hierarchy consisting of at least a chief administrative officer and some assistants to the superintendent, sometimes called deputy, associate, and/or assistant superintendents. Others may include directors, supervisors, and consultants as part of the hierarchy. All have principals to round out the educational leadership group. The members of the management team may be separated by many or few layers of authority depending upon the size and complexity of the system. Communication may be informal and on a face-to-face basis, or it can be formal and follow channels of communications in a precise form and manner. Delegation of authority may be practiced in various degrees to limit or expand the capability of administrators at various levels to commit the resources of the district for different purposes. In some smaller school districts the superintendent functions as *the* decision maker, and few assistant superintendents, directors, or principals, much less teachers, participate in the process. Unilateral action was difficult to justify years ago and is even more difficult to defend in a complex institution during turbulent times.

The traditional bureaucratic model worked well in maintaining the status quo. Existing organizational charts assume that the administrator is concerned solely with operating schools in an efficient manner. New instructional approaches; activism by pupils and personnel; the dynamic nature of local, state, and federal power structures; and rising expectations are not adequately dealt with in the old organizational model. Above all the model was created and adapted to a pre-technological era, when most of what could be done was manual in approach and historical in perspective.

Insofar as the systems technology is an approach that seeks to anticipate likely consequences prior to committing massive resources, the new organizational model must be future-oriented. Just what it will look like no one knows for certain, but some factors are beginning to be recognized as significant in present-day efforts to generate a new organizational model. To begin with, the systems approach demands a sharper delineation of administrative responsibilities. Poorly defined functions and fuzzy relationships break down quickly when tested by the change to the new decision technology. Secondly, top-echelon administrators will be concerned more with defining and redefining educational missions and priorities and less and less with operational activities. Planning and future-oriented functions will be granted high priority at this level. Coordination of a variety of specialists will be a major responsibility as well. Second-echelon administrators (assistant superintendents, directors, and principals) will focus on executing operational activities. It is at this level that decisions will be made on how educational tasks are to be handled. Feedback data become important to second-level administrators who can then trigger corrections that determine when an activity is to be recycled, altered, or changed.

The systems analysis approach to problem solving sees the chief administrator as responsible for the management of the entire decision-making function. As Herbert Simon commented:

> The executive's job involves not only making decisions himself but also seeing that the organiza-

> tion, and parts of an organization that he directs, makes decisions effectively. The vast bulk of decision-making activities for which he is responsible is not his personal activity, but the activities of his subordinates. . . .
>
> There is no reason to expect that a man who has acquired a fairly high level of personal skill in decision-making activity will have a correspondingly high skill in designing efficient decision-making systems. To imagine that there is such a connection is like supposing that a man who is a good weight lifter can therefore design cranes.[1]

The advent of cybernation and the recent extensions of the scientific approach to problem solving emphasize a more rigorous analysis and synthesis of the decision-making process. The process depends upon detailed examination of procedures related to the systems approach and the creation of an administrative apparatus which will ensure the effective application of systems thinking. The following conception by Young and Summer seems to be descriptive of such an administrative apparatus.

> A management system can be defined as that subsystem of the organization whose components consist of a subset of individuals (man to man) whose duties are to receive certain organizational problems (inputs) and thereupon to execute a set of activities (process) which will produce organizational solutions (output) for either increasing the value or return of the total organizational activity (satisfying) or for optimizing some function of the total organizational inputs and outputs.[2]

The value of this conceptualization lies not only in its structure and ready application to educational administration but also in its focus on the need to use the rigor implied in the systems analysis approach to problem solving in studying the interrelationship of its component parts.

Systems Demands Total Staff Participation

An analysis of the organizational pattern in terms of its decision-making levels and staff competencies is an important first step in the implementation of administrative technology. Who has authority or responsibility to make what kind of decision? Authority to make delegated decisions implies that it is unnecessary to clear the action with a superior in the hierarchy. It also implies that guidelines for decision making exist. However, it does *not* imply that those in superordinate positions are to be kept ignorant of the decision made or its consequences.

The systems approach recognizes that action taken at one point in the system may in some way affect the behavior of others at different organizational levels. Specifying objectively the goals of a given operation and sensing how these may influence missions of another level is essential. Many performance goals are determined by specialists familiar with the particular unit within the school, but who may be unmindful of the functions of other educational and social agencies within and outside of the system. Specialists are found throughout the school organization in fields such as business operations, personnel, counseling, teaching, and the like. These can be conceptualized in levels. The higher up the hierarchy one goes, the more important the coordination functions become, particularly if staff involvement is stressed or maximized. Likewise, as a person moves up the organizational hierarchy, more of his time will be devoted to the planning function and consequently less is available for other administrative activities.

FIGURE I

Level I	Superintendent	Generalist or comprehensivist with concern for the total system and coordination of all units

Level II	Assistant Superintendent	Quasi-generalist or quasi-comprehensivist with concern for interrelations within a major subdivision of the system
Level III	Principals	Specialists with concern for a significant component in the system
Level IV	Teachers and Special Service Personnel	Specialist within component units

Figure I suggests that the further down the line an activity is placed, the greater the degree of specialization and focus on the task. Teachers have responsibility for the most specialized task consistent with the major goals of the school system: teaching children. Thus, when setting concrete, operational, and measurable instructional goals, the entire organization must depend upon the teacher as a specialist in a given curriculum area. For example, if a school district has no mathematics consultant to help establish objectives, the mathematics teacher becomes the most crucial determiner of goals in this subject area. In this perspective the teacher's role takes on a much different meaning. The teacher is no longer merely an implementor of policy; he assumes a position of authority in the development of policy related to his specialization. Thus, the teacher is programmed into the systems decision-making process in problem solving.

One of the benefits accruing from greater teacher involvement in goal setting is the minimization of communication problems generated when data available to administrators through the feedback process for evaluation of instructional goals and policies are insufficient or inaccurate. Another benefit is a more reliable basis upon which to evaluate teaching effectiveness. Past evaluation focused primarily upon the teacher's individual characteristics, for example, compatibility and process. The establishment of measurable instructional goals now permits teacher evaluations to be couched in terms of the degree to which a teacher has been able to meet those goals.

Goals expressed in terms such as "education for citizenship" do not provide an adequate basis for evaluation of outputs. They hinder rather than help efforts to improve the organization's efficiency and effectiveness. Goals must be translated into discernable units with appropriate indicators of change, with definable increments that are within the range of measurable phenomenon. Developing citizenship must be operationalized in terms of skills, knowledge, and attitudes to be acquired or behavioral patterns to be developed.

The foregoing example dealing with specified content and methodology points up some of the difficulties surrounding past evaluation of teachers by most principals and supervisors. It also gives credence to the desirability of allowing the specialist to set goals and establish strategies to accomplish these goals. Paraphrasing Max Ways, the superintendent, his assistants, principals, teachers, and business officers dedicated to implementing administrative technology should—

> 1. Give deliberate attention to the selection of *ends* toward which planned action is directed and increase efforts to improve planning by sharpening the definitions of ends.
>
> 2. Develop a more systematic advanced comparison of means by criteria derived from the ends selected.
>
> 3. Develop a more candid and effective means of assessing results, usually including a system of keeping track of progress toward interim goals. Along with this goes a "market-like" sensitivity to changing values and evolving ends.
>
> 4. Make a deliberate effort, often intellectually strenuous, to mobilize science and other specialized knowledge into a flexible framework of information and decision so

that specific responsibilities can be assigned to the points of greatest competence.

5. Place major emphasis upon information, prediction, and persuasion rather than on coercive or authoritarian power as the main agents of coordinating the separate elements of the school system.

6. Constantly work at increasing the capability of predicting the combined effort of several kinds of simultaneous action on one another; this can modify policy so as to reduce unwanted consequences, or it can generate other lines of action to correct or compensate for such predicted consequences.[3]

Frequent references have been made to the "new" approach to administration and its associated tools, PPBS or PERT. A word of caution is appropriate here to warn that emerging technologies are not panaceas for all organizational ills. Furthermore, every approach or technique requires a degree of artistry on the part of the user to maximize its benefits. One writer cautioned that while all aspects of education may benefit to some degree from systems analysis techniques, it would be unfortunate to expect answers to all educational problems to come from this one source.

IMPLICATIONS FOR IMPLEMENTATION

Operational systems do not emerge overnight in viable form, capable of self-support. Implementation can be accomplished in both large and small districts through a judicious mix of available internal and external resources based on defensible plans. The degree of viability and sophistication will of course vary.

Administrators may intuitively perceive a multitude of implications arising from the emerging administrative technologies. These include many of the following:

Implication 1: Administration and Board Commitment

The first prerequisite in developing a systems approach embodying administrative technology was reviewed in an earlier chapter, namely, the board and superintendent must have a mutual commitment to the systems approach. Boards of education must come to view cybernation and systems in administrative problem solving in their social context, that is, in their relationship to the goals of education.

Implication 2: Strategies for Beginning

Few, if any, industries and no school systems to date have a complete systems operation which covers every aspect of the organization. Perhaps a sound approach to the problem of adopting administrative technology in any school system is to start with the easier to comprehend and utilize scientific tools now available for solving problems.

Some may purchase a ready-made system of administrative technology. It may involve some "cutting and pasting" of an approach found successful in a business enterprise or simply the purchase of a specialized service from a consulting firm. A superintendent should not be expected to develop a systems approach to school administration by himself. Rather he should make use of the sources available to him. Caution should be exercised in the selection of a consultant firm; the firm should have a real understanding of the educational enterprise and be sensitive to the unique problems of the school system.

The strategy may begin with a feasibility study. Here consulting help from a university (only a few do this now) or from private consulting agencies (only a few have staff competent to work in educational organization) would be most useful. The feasibility study could reveal:

1. The nature of planning necessary.
2. Components of the organization in which certain

operational research techniques could most readily be applied.

3. The extent of readiness and capability of the staff in the organization to implement the approach.
4. The in-service training necessary for existing staff.
5. The kind of additional staff needed.
6. The kinds of results in terms of efficiency if a system were implemented.
7. The cost to the school district.

The answers to these and other questions are necessary before a district decides to implement the systems approach.

Implication 3: Developing Staff Competencies

The skills and abilities required to implement this systems approach may require employment of special talents and/or development of such competencies in existing personnel. This may call for the establishment of local study committees, extension classes, summer school, and/or sabbatical leave opportunities for staff members. It is anticipated that staff not only will study their particular subject matter specialty or area of business concern but also will concern themselves extensively with a study of the systems approach to problem solving. From this it will no doubt be found that certain persons on the staff are especially adept in the ways of systems thinking.

Implication 4: Total Staff Involvement

To be truly effective, the systems approach must rely on collectivity. Even though the major responsibility for framing problems, defining objectives in quantitative terms, and formulating alternatives lies in the central systems staff, the administration *must* look to teachers for advice on problems arising in the area of their unique competency. This is essential since ultimately they will be responsible for implementing any decision arrived at by the systems staff.

Implication 5: The Systems Specialist in the Administrative Hierarchy

Every administrator, supervisor, and teacher has an integral role to play in making the systems approach operational. Systems is a mission-oriented approach, and persons responsible for mission accomplishment must view their responsibilities in an analytical way.

Nonetheless, specialized talents are imperative. The systems specialist or analyst is an important new member of every administrative team. In addition to his commitment to the scientific method and his recognition of the whole organization, the systems analyst has the quantitative operational skills of the statistician and mathematician to construct quantifiable models for simulating operations and to solve complex mathematical problems. Furthermore, his ability to work with behavioral scientists, such as economists or sociologists, and other task force members is important.

A school system over a period of time would no doubt develop a team of analysts. The quantitative analyst is useful to all departments of the organization; however, large school systems would want to consider an analyst with a sociological or political orientation. Certainly every school system is concerned with learning, and a psychologically oriented analyst concerned with instructional problems and institutional systems would be useful.

The departments of the school organization most amenable initially to implementing the systems approach are the business or other noninstructional units, i.e., finance, building, and inventory control. Here the quantitative-oriented analyst would be the most useful. However, improvement in the quality of an educational program necessitates attention to appropriate measurement techniques in these areas as well.

Analysts working in an educational organization must possess an understanding and feel for that which they are helping to quantify, order, and analyze. Thus, while all analysts should have a background in education, they do not necessarily have to have a complete understanding of every facet of the entire system since they will function as a member of a team.

In summary, the systems analyst with the insight, experience, and preparation to comprehend the substantive problems of an organization is a person who has acquired highly developed skills in the use of sophisticated quantitative analysis techniques but at the same time possesses a very sophisticated understanding of the missions of educational institutions. He is a person knowledgeable about education and/or administration and is thoroughly schooled in systems analysis.

In addition to a background in education, a description of the systems analyst must contain some of the tools which he must utilize. Young and Summer devised the following list of tools, grouped according to their 10-step breakdown of problem solving.[4]

Problem-Solving Tasks	*Tools and Techniques*
1. Definition of Organizational Objectives	(a) Welfare, utility, benefit, or value measurement theory
2. Raising the Problem	(a) Sampling theory (b) Reliability analysis
3. Isolating Determinants	(a) Partial correlation (b) Multiple correlation (c) Regression analysis (d) Factor analysis (e) Model building: 1. Physical 2. Abstract 3. Mathematical 4. Statistical (f) Controlled laboratory experiments (g) Historical analysis

	(h) Personal estimation
	(i) Logical deduction
4. Search for Solutions	(a) Search theory
	(b) Heuristics
	(c) Information theory
	(d) Linear programming
	(e) Nonlinear programming
	(f) Dynamic programming
	(g) Simulation
5. Selection of Best Solution	(a) Cost accounting
	(b) Linear programming
	(c) Information theory
	(d) Heuristics
	(e) Nonlinear optimizing
	(f) Dynamic programming
	(g) Invention
	(h) Probability theory
	(i) Sampling theory
6. Consensus	(a) Group dynamics
	(b) Information theory
7. Authorization	(a) Theory of risk
8. Implementation	(a) Critical path
9. Direction	(a) Sampling theory
	(b) Reliability
	(c) Servo theory
	(d) Information theory
10. Auditing	(a) Sampling theory
	(b) Reliability
	(c) Servo theory
	(d) Information

A NEW PATTERN OF OPERATION BASED ON SYSTEMS

The typical person in the second and subseqent echelons of an educational organization is charged with the responsibility of advising or informing those in superior positions in the hierarchy. Drucker questioned the concepts of authority and responsibility of such line-staff relationships:

> Authority and responsibility may well be the wrong principles of organization. It may be that we will have to learn to organize not a system of authority and responsibility—a system of command—but an information and decision system—a system of judgment, knowledge, and expectations.[5]

If the above concept is accepted, then a major concept of organizational change would be effected. The emphasis would be on information (output, feedback, analysis, and evaluation). At present the superintendent may employ the public media, bulletins, or talks to inform the personnel in the school system and the public on what actions his board has taken. He currently has little opportunity for accurate and well-organized feedback and lacks the necessary mechanism whereby he can advise a board on a proposed alternative in light of the resultant conseqences of that alternative on children.

The local school system has been perceived as an instrument of state and federal social planning. Federal concerns with poverty, racial and ethnic discrimination, and cultural deprivation have been put into action through state and local school systems. PPBS is being promoted by the federal government as a way to measure performance against resources allocated to attain a given mission. The goals, however, have been defined at the federal level, as well as the suggested means for reaching them. In many cases the goals are vaguely defined or the educational outcomes expected are not expressed in operational terms. For instance, the goal of eliminating de facto segregation in school systems calls for working with minority groups (racial, ethnic, or social) in a given way. The indicator of accomplishment in this particular case is a quantitative estimate or numbers of certain types of students in certain types of situations (how many white pupils and how many black students in a given attendance center?). The argument for releasing the black child from the ghetto is persuasive. These and similar goals must be translated into operational terms so that over a period of time it can be determined what is actually happening. Right now the federal government is using legal rather than educational evaluation, and the emphasis is on means rather than ends.

Operations research teams must be sensitive to both internal and external demands on schools. Something akin to radar is needed to scan public concerns locally, statewide, and nationally. Such data may define whether assumed ills actually exist and if the mounting pressures have a basis in facts. Systems analysis to determine optimum strategies will function best where accurate data exist. Systems analysis alone cannot force a school district to change. All it can do is demonstrate the likely consequences of various courses of action. Organizations, especially public ones, have a propensity for justifying present behavior. Systems analysis and operations research may or may not alter the psychology of decision makers.

If the school system is to be organized on the basis of an information and decision system, then there must be a means for determining what information is important to whom, how it is organized, and how it should be interpreted. Emphasis should be on what information sheds light on progress toward goals and its relation to many subparts of the organization. The term "system" implies an orderly process where each part of the organization is coordinated with other parts. The term "information" as used here implies organized and meaningful data. It may be expressed in terms of key variables for a given point in time. As new variables are introduced (whether from external pressures or from new internal practices) each can be described in terms of what impact each will have on the system.

The majority of school systems are organized and staffed to cope with day-to-day operational problems. The typical principal or central office staff member is so busy with current concerns that he has little time or concern for system-wide problems or long-range planning. If there is to be long-range planning and system-wide analysis of problems and decision making, there must be appropriate technology and staff support. This implies an orientation of staff to long-range planning and a systems approach to the decision-making process.

The posture of the superintendent is unquestionably a factor in endeavoring to implement a system of administrative technology. It was stated earlier that the superintendent's desire for change and innovation as well as his willingness to commit his own and his staff's energies to these ends is of prime importance in effective implementation.

The superintendent's support of principals and central office staff is crucial in buttressing them against uncertainty, especially where there is fear of possible failure related to adoption of a new approach.

Demands for innovation and change made upon principals and central office staff will call, in turn, for their support of classroom teachers. When teachers and staff all agree innovation and change are desirable and even imperative, implementation of technology has a chance for success. It is at this point that a whole series of new problems arise, such as retraining and recruiting staff and phasing out old practices when the new system is fully implemented.

If the preceding concepts of present staff limitations and strategies for implementation are accepted, there is a greater likelihood that specialized supporting staff can be employed successfully in systems operation and long-range planning. The tools of administrative technology demand special skills and abilities. In most school districts this will not mean a call for more of the same kind of staff members, but for the addition of administrative, supervisory, and technical specialists who can manage information files, frame problems to facilitate prudent decision making, and who have the concepts and skills needed for utilization of systems techniques and procedures.

Effective implementation calls for the creation of a new division of systems analysis, or a redefinition of the typical research division found in many school systems and state departments today. A research, planning, information, and development division (RPID) is suggested. Any school district in a city of 30,000 or more should have such a division. Smaller school districts will be able to do much with adequately trained administrators and principals and with the help of an intermediate or state service area. The emphasis in this division should be on ideas and software; this should determine the hardware. The personnel in the systems analysis division would include some permanent staff, such as operations research and systems analysis specialists, information specialists, measurement personnel, and computer specialists. In large school systems and state departments of education, there might also be an economist, sociologist, psychiatrist, political scientist, and urban planner, as well as specialists in population projection, federal relations, community relations, and program budgeting.

There would also be a sizable staff from within the school system assigned to the systems analysis division on a temporary basis (administrators, teachers, specialists of all kinds). These people would set goals, examine and describe existing programs, and then with the operations research or systems specialists determine the strategies to accomplish the goals and the means for feedback to various personnel to monitor how well the system works. The director of RPID should report to the superintendent of schools. His staff would be responsible for the preparation of concise reports to the superintendent dealing with what was being done and evaluating how well the system was functioning.

Considerable staff help on planning problems might well be obtained from personnel in universities, government agencies, or private firms on an ad hoc basis. In adding staff on either a temporary or permanent basis, it is important that the persons recruited have educational vision and innovative spirit, as well as the technical skills required for the job.

It would appear that over a period of time a school system might develop a team of analysts. A quantitative analyst is useful to all departments of the organization. Large school systems might want to consider another analyst with a sociological or political orientation. Since above all, every school system is concerned with learning, adding a psychologically oriented analyst concerned with instructional problems and institutional systems would seem highly desirable.

In summary, the system analyst should have insight, experience, and preparation to comprehend substantive problems of an organization, should have acquired highly developed skills in the use of sophisticated analysis techniques, and should possess an understanding of the missions of educational institutions.

The need for an RDIP division is present in every state department of education. State planning cannot be accomplished or should not be done separately from the local school system. Local system planning depends upon state planning. Therefore, a comprehensive network of information exchange is essential.

At the federal level an RDIP division is needed so that the U.S. Office of Education can monitor itself. This office is extremely vulnerable to variables over which it has little control. Planning and anticipating changes is an essential function of this office.

Universities must build staff competence in the new administrative technology in order to help provide in-service education to public school staffs, provide consultative services for local school districts, and develop future school personnel with competencies in the new administrative technologies. With respect to future school personnel, university programs for school administrators should be organized around subject matter which produce administrators conversant in the new technology. The prospective administrator should gain competencies in organizational theory, human behavior in organizations, data processing and computer concepts, systems thinking, statistics and measurements, and management information systems concepts. He should also be exposed to operations research techniques. In addition, internships and on-campus practicum courses designed to provide experience in systems thinking should be offered.

SUMMARY

Rising expectations as to what public schools can and should accomplish is causing a profound impact on school administrators. The nature, number, and scope of problems besetting school systems today necessitates a look at new methods of problem solving, decision making, and long-range planning. Administrative technology holds forth real promise in these areas.

Before there can be successful introduction and implementation of administrative technology in any school, the administrator must have a clear concept of the total systems approach: its purpose, nature, elements, and interrelationships.

The conceptual framework presented for consideration is based upon improving the decision-making process of administration, thereby improving the efficiency of the total school system in producing its end product: the educated person. With this basis, certain components of a conceptual framework are considered. These are clearly defined goals, file management, flexible input coefficients, cost cognizance, effective communication, and improved tools for decision making.

Implementation of administrative technology is not a one-time or single year's effort but must be carefully planned and executed over a relatively long time span. Operational systems such as the ones discussed in this volume do not emerge overnight in viable form, capable of self-support.

Because of the nature and scope of problems of implementation, it seems desirable for administrators to establish their own order of priorities for action in their individual school systems. Suggested priorities meriting consideration are preservice preparatory programs, organization for change, total staff participation, development of administrative and board commitment to a systems approach, sharpening of administrative responsibility, and improved means of foreseeing future problems.

Traditionally, administrative and supervisory personnel are involved in operational activities. Few, if any, are concerned with research or long-range planning. Most schools lack systems capability for such tasks. Successful introduction and implementation of administrative technology call for total staff support. This involves orientation of present staff, employment of supporting staff with specialized capabilities, and creation of a division of systems analysis. The key person in the supporting staff is a systems analyst responsible for the operation of the entire system and its subsystems. It is important not only that the systems analyst be trained and experienced in his specialized field, but also that he have a broad understanding of education and its unique problems. The size and scope of the division of systems analysis will determine the number and specialized training of additional staff members.

In general, effective implementation of administrative technology depends upon:

1. Clearly defined and measurable goals
2. Wholehearted acceptance of the systems approach by boards of education, administrators, and teachers
3. Flexibility in moving toward innovation
4. Staff competencies in systems development
5. Greater and more skillful use of electronic and mechanical devices
6. Efficient file management
7. Collaboration with other systems and agencies in research and development.

When a systems approach is implemented and operational, the following outcomes may be expected to appear gradually:

- Improvements in decision making
- Increased number of facts and alternatives available as basis for sound decisions
- Improvements in handling of problems
- Better detection of mounting pressures on the school system, both internally and externally, and their validity (Here the systems approach performs a radar function.)
- Foreseeing future problems in time to prepare possible courses of action
- Making available many alternative strategies and solutions to anticipated problems
- Improvement in long-range planning
- Greater acceptance of innovations
- Freeing of administrative time for innovative thinking
- Provision of means for evaluating innovations being tested
- Improvement of efficiency of total operation of school system

- Monitoring of total school system
- Obtaining accurate feedback
- Establishment of "flag points," i.e., points at which corrections should be made
- Improvements in communications within school system and between school and community.

Administrative technology certainly is not a panacea for all of the problems facing public schools today. In education as in business, introduction of technology offers great potential for long-term gains, but the initial period of development and implementation may be a difficult one and may even create new problems. Superintendents should avoid the temptation to accept untested practices and unrealistic techniques tested in pilot school settings and demonstrated to be successful in bringing about productive changes.

While reading and talking about administrative technology are necessary preliminary steps, none of the benefits of a systems approach will ever be realized until administrators actually take steps to put such an approach into practice in their own school systems. Introduction and implementation of administrative technology calls for bold action on the part of a superintendent and his staff.

FOOTNOTES

[1] Simon, Herbert A. *The New Science of Management Decision*. New York: Harper & Row, 1960. pp. 4-5.

[2] Young, Stanley, and Summer, Charles E., Jr. *Management: A System Analysis*. Glenview, Ill.: Scott, Foresman & Co., 1966. p. 15.

[3] Ways, Max "The Road to 1977." *Fortune,* 75:95; January 1967. p. 95.

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CHAPTER 6

Operations Analysis: Some Concepts and Techniques for Education

Systems technology emphasizes a more disciplined and more quantitatively oriented reasoning approach to scientific problem solving. This approach will be identified henceforth by the term "operations analysis." It is literally an analysis of operations—educational, business, or governmental—with heavy reliance on the generation of mathematical models that may appropriately describe the key factors or variables and the relationships between them. It is a highly rational search for optimum solutions but by the same token may be more complex and hence more difficult to comprehend.

Applications are beginning to emerge in education, although they are somewhat limited as yet. Where educational and noneducational organizations experience similar problems such as routing supplies, transporting clients, planning large-scale construction projects, or inventorying supplies and equipment, applications in the management of noneducational enterprises may, with some adaptations, be useful in the administration of schools. This is not to suggest that operations analysis in education must be confined to such problems. There doubtless will be systems applications to the more difficult and crucial decisions to be made by school executives. This AASA Commission hopes that the illustrations here can serve as points of departure to general problem-solving techniques that may replace in large part the predominately intuitive techniques that characterize school administration at this time. It must be reemphasized that although the illustrative materials are drawn from school food services, transportation, and student scheduling, systems technology in education will someday have a much wider range of applications.

Computerized School Lunch Menu Planning

There are at least two major areas of concern in food services management: menu planning and administrative services. Approximately two-thirds of the costs are incurred in the first; the remaining one-third, in the second. To minimize costs in the total food service operation a complete systems study of all aspects of operations may be necessary. This involves a complete cost analysis.

A breakdown of unit costs in food service operations can show the impact of each element—such as labor used in food preparation and serving, overhead expense of supervisors and administrators, purchase price of individual food items, and utilities—on the menu costs. These can then be related to the maximum allowable, that is, the price paid by the student for the food service. The detailed cost control is a fundamental part of food service management that seeks an efficient system for satisfying the clients served.

Cost analysis can be facilitated with the electronic computer. Computerized menu planning takes advantage of a comparatively new technology to store, compare, and retrieve bits of information important to rational food service management. The computer makes it feasible to utilize sophisticated mathematical approaches, such as linear programming. This quantitative procedure makes it possible to relate a large number of variables involved, to rank each according to cost, and to determine optimum combinations of food items that comprise a school lunch that satisfies nutritional standards, taste preferences, and food presentation preferences (based on color, shape, variety, flavor, and texture) of children and youths being served.

The traditional approaches to this common school problem are experimental and intuitive. The school lunch manager feels he knows the most efficient menu as well as the most satisfying one. In this day of mounting costs and narrow margins between break-even points and losses, this may not always be the case.

Systems technology lends itself readily to the various management problems encountered in school food services operations. The more complex these services become and the larger the resources allocated to such purposes the more feasible, and perhaps even imperative, it becomes to use operations analysis as a tool in decision making.

Computerized Educational Transportation Application

The basic problem associated with educational transportation (after appropriate cognizance is taken of political constraints) involves assignment to a given location and determination of routes to such locations. In education this means that students are picked up at given points by vehicles of stated capacity and transported to assigned school centers. There is the additional constraint that transportation shall be executed at the minimum cost.

In a typical district schools and students are scattered throughout a rather large geographic area. If the concern is for assigning students to school centers in such a way as to minimize the distance all students travel, then the basic quantitative analysis technique would be what the mathematicians call the linear programming algorithm. The linear programming model is a mathematical routine that assumes that there are certain items to be picked up at one location and deposited at another with the constraint that this is to be achieved with a minimum cost. It can be viewed as a mixture or arrangement problem of sending items (pupils) to appropriate locations (schools) so that the distance (cost) will be minimal.

The second phase of the problem is to route buses servicing a given school in such fashion that the distance buses travel will be no greater than necessary. The transport routes can be generated by a computer which is called in to solve the mathematical problem. These computer-developed bus lines can be drawn on a map to verify the validity of the procedure.

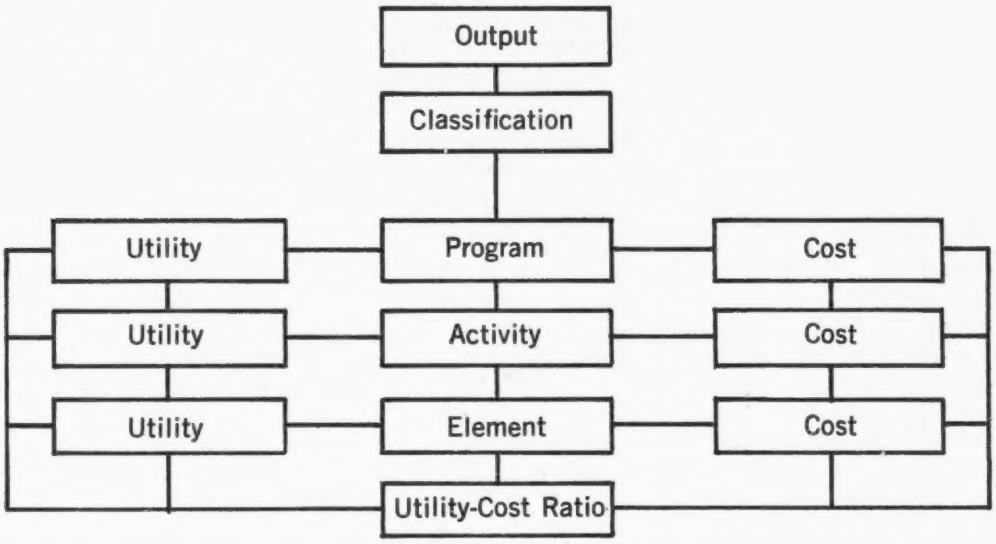
The flexibility of computerized transportation planning is substantial. The computer program can be modified to work within the constraints specified by the transportation manager, whether these constraints be political or physical, e.g., water barrier or dangerous crossing. Of course, the transportation problem is being solved every year on an intuitive basis by school officials throughout the country. What makes transportation a good illustration of operations analysis is that it is systematic enough to lend itself to analytical techniques.

Utility-Cost Resource Allocation System

The increasing magnitude and complexity of local educational systems necessitate more sophisticated procedures for making decisions regarding the allocation of educational resources. Such allocations should be based upon educational objectives and optimum returns for the resources invested. A utility-cost resource allocation (UCRA) model has a contribution to make to local school districts. A UCRA system associates costs and utilities for each alternative for reaching an objective. The model requires the determination of three major factors:

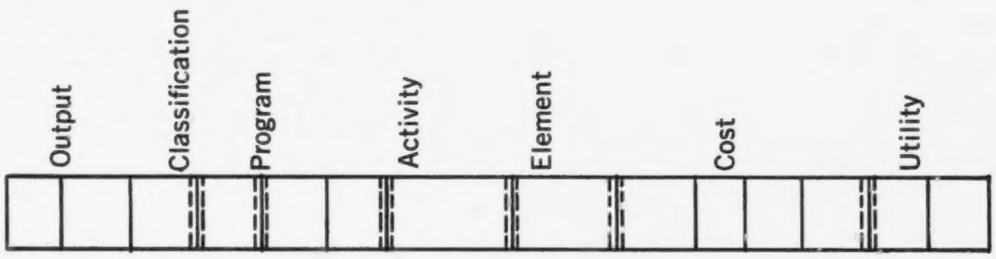
1. Actual and desired educational outputs (i.e., students prepared in specific areas)
2. Programs, activities, and elements associated with educational functions
3. Utilities and costs associated with programs, activities, and elements relevant to educational goals.

The UCRA model provides a rational basis for fiscal planning. It has the advantage of greater objectivity and efficiency, since the system is based upon outputs, activities, utilities, and costs often not considered in less sophisticated approaches. The following diagram is illustrative of the overall design and expected outcomes.



The above illustration shows utility-cost relationships for programs, activities, and elements. Utility-cost ratios are basic to decision making for relevant information is furnished to assist the administrator in the allocation of resources.

The computer coding scheme is of the following form.



It will furnish a computer record for storage retrieval and comparisons. The coding scheme that follows illustrates how the various categories might be defined.

Output = A skilled computer programmer
Classification = Instruction
Program = Level of mathematics skill to be achieved
Activity = Algebra concepts to be learned
Element = Teachers involved
Cost index for inputs = 0.20/hour
Utility index = 0.50

This suggests that one could use the model to compute the cost of (a) a preparation program for a specific job (computer program), (b) the total instructional program, (c) the mathematical skill development program, (d) the program activity, and/or (e) the basic input elements, classifications, programs, or activities. The element is the basic unit in the building block system. Since costs and utilities are additive, utility and cost numbers will be ascertained for elements. To determine the utility or cost of the acquisition of algebra concepts, merely add the utilities or costs of all the elements associated with the algebra activity.

More important than determining program costs per se, the model would permit comparative costs and utilities to be made for different programs or activities. In this fashion more objective decisions could be made regarding the proportionate amount of resources to be allocated among programs.

It must be emphasized that cost is only one element in the model and usually is the easiest to determine. The so-called utility function of an educational program is far more difficult to compute and interpret. At present there is only meager information on the utility (call it relevance or usefulness) of a given educational experience during the long and unpredictable lifetime of a student. The arbitrary utility index of 0.50 assigned to algebra concepts in the previous illustration is just that, a figure picked at random. A utility-cost resource allocation system is of assistance to administrators who have responsibility for obtaining and allocating resources for the operation of the total school system. Its effectiveness will be determined in large part by the indicator used to measure the utility of a given experience. This is not a reincarnation of the approach used some 50 years ago—and rejected—which called for making decisions on what to offer in schools on the basis of what costs the least. This is better identified as searching for the greatest educational value (utility) with the least expenditure (cost). In order to formulate the utility-cost resource allocation system, utility numbers must be derived for specific activities and the cost of those activities must be derived. The following steps are required.

Numerical values are assigned to utility functions associated with given activities. These utility numbers are relative numbers scaled from 0.00 to 1.00 and normalized over the entire range of activities. An illustration might help to elucidate the point:

1. Assume five activities—a(1), a(2), a(3), a(4), a(5).
2. Arbitrarily assign numbers to each of these five activities, e.g., 100, 50, 30, 20, 10.

3. Compare a(1)> a(2) + a(3) + a(4) + a(5), i.e., 100> 50 + 30 + 20 + 10.
4. Adjust the numerical value assigned to a(1) to verify the inequality, e.g., 120> 50 + 30 + 20 + 10.
5. Assume that a(2) is greater than the remaining three values associated with the other three activities, e.g., 50> 30 + 20 + 10.
6. Adjust a(2) to make that inequality hold, e.g., 70> 30 + 20 + 10.
7. Adjust a(1) since a(2) has been adjusted, e.g., 140> 70 + 30 + 20 + 10.
8. Set a(3) greater than a(4) and a(5), e.g., 30> 20 + 10.
9. Do the necessary adjustments, e.g., 40> 20 + 10.
10. Make the necessary adjustments to a(2) and a(1), e.g., 80> 40 + 20 + 10; 160> 80 + 40 + 20 + 10. The resulting five utility numbers, i.e., 160, 80 ,40, 20, 10, which are now associated with the respective five activities represent a quantitative conversion from the qualitative judgments associated with the utilities of the five activities.
11. Add the five utility numbers and divide each utility number by that sum, e.g., 160 + 80 + 40 + 20 + 10 = 310; therefore, 160 ÷ 310 = .516, 80 ÷ 310 = .258, 40 ÷ 310 = .129, 20 ÷ 310 = .064, 10 ÷ 310 = .032. This will normalize the values of those utility numbers and place them somewhere between 0.00 and 1.00.

This simplified procedure for converting qualitative information into quantitative information denotes a point of departure from which the utility values are eventually utilized. Again this conversion process is based on a subjective value judgment made when a number value is assigned to the qualitative data. These utility numbers are building blocks based upon the basic elements associated with each activity. That utilities are additive has been proven in mathematical utility theory and will not be treated here. It is not necessary for the system administrator to be a mathematician, but it is important to have someone on the administrative team with such capability. If this is not possible, then there must be access to consultant services with administrative analysis skills. The basic formula, however, is $U(A) = U(A_1)p_1 + U(A_2)p_2 + \ldots + U(A_n)p_n$, where $U(A)$ = utility of A, $U(A_1)$ = utility of A_1, and p_1 = probability of A_1. The additive property of utility theory is essential to the formulation of utility numbers which are associated with the activities and programs because the utilities are built upon elements. The utility of an activity or program is read as follows: $U(A) = U(E_1)p_1 + U(E_2)p_2 + \ldots + U(E_n)p_n$.

After the utility index and cost index are derived and assigned according to element, computer programs are used to allow quick information retrieval relative to the utility of a program, the cost of a program, and the utility-cost ratios so that different programs or activities can be compared. A computer readout can be obtained on current manpower outputs, required manpower outputs, relative values of different programs, and relative information regarding the expected value or payoff from resources allocated to particular areas of interest.

The final aspect of the utility-cost analysis is the formulation of a procedure whereby resources can be appropriately allocated to the most desirable outputs according to utility. The computer program may be designed to obtain an output of frequency distributions for local and national major occupational categories and also for the proportionate amount of resources allocated to each major occupational category. Such outputs enable school officials to monitor resource allocation patterns. Included with the occupational categories are data related to personal investments, so that the final output includes the relative distribution of resources across occupational skills and personal investments. The UCRA system categories can be plugged in according to the desires of local decision makers. The model is not tied to any given philosophy translated into such objectives of education as to whether to prepare the individual for an occupation or for effective living. The assumption of this model is that both concerns are important, and the relative proportion of resources to be allocated to each can be determined by local desires.

Student Scheduling

Student scheduling is a classic example of the payoff associated with the new educational technology. Student scheduling must be done, is time-consuming in large attendance centers when done manually, becomes increasingly difficult with complex programs, and lends itself well to automation.

The Commission is well aware of the problems that have been experienced when introducing computer-based student scheduling. Most can be traced to the newness of computer programs, persons responsible for scheduling are not as familiar with the computer routines as they should be, and attempts to use computer routines with unsuitable educational organizational arrangements. Effective student class scheduling is now possible if the user either writes computer programs for his specific schedule (particularly if that schedule is esoteric) or uses well-tested programs where applicable.

Several computer manufacturers have designed routines for scheduling students to classes with the assistance of a computer. The process may start with each student being furnished with a list of courses to be offered, usually called an educational program planning guide. The student merely circles the number assigned to each course he, his counselor, and/or his parents believe should be studied during the coming school term. After all students have made their course selections for the term, the selection sheets are sent to the computer-based data-processing center for initial analysis. The computer is programmed to manipulate the input data to determine the number of pupils desiring each course offered at each period it is available with further appropriate breakdowns as to grade level or sex of pupils. The computer also may be directed to identify potential schedule conflicts for various pupils, such as two desired courses offered during the same time period. This is the well-known conflict matrix that principals have wrestled with without the help of a computer for many decades. The steps followed in student scheduling by computer are quite similar to the traditional approaches. The computer does it faster in most instances. The master class schedule is the product or output of the electronic computer which in large systems is likely to be more accurate in relating details than intuitive and manual procedures.

PERT

PERT is one of the developments in administrative technology that can sharpen the planning, controlling, and decision-making skills of school administrators forced to deal with a world in a state of flux. It is new or old depending upon one's perspective. It has been employed in managerial endeavors for at least a decade, and it still continues to be perfected. During the last two or three years PERT has been referred to with increasing frequency in conversations among school administrators. PERT is related to another network modeling technique called CPM or critical path method.

PERT has been used to predict likely snarls in a complex project and to facilitate prudent use of resources assigned to a project. It is presently employed by many governmental agencies, both military and nonmilitary, to cope with complex projects and is accepted by forward-looking administrators in the business world as well. It can be adapted readily to school administration.

PERT Defined

PERT is an acronym. Its name is derived from the first letters of "Program Evaluation and Review Technique." As the name implies, it is a technique for evaluating and reviewing progress toward a stated goal. It goes beyond postmortem analysis.

A word of caution is in order. PERT is no more a cure-all than any other administrative technique. A craftsman knows when, where, and how to employ a given tool. Doubtless, the demand for new administrative skills to make operational, as rapidly as possible, the ever-increasing number of inventions that keep streaming out of the scientific laboratories stimulated the development or technique. PERT's primary contribution is in dealing with so-called once-through projects rather than repetitive activities. It is useful in planning and controlling the curriculum project, the special federal grant, or the new school plant.

The list of projects in education where PERT could be applied would be a long one, limited only by the imagination of the compiler. Using it in one place triggers suggestions for others. It could be employed in planning and constructing new school plants, planning and developing research projects, organizing and operating testing programs, organizing conferences or conventions, designing curriculum study projects, and the like. As an administrative planning control and decision-making tool, PERT is based on a breakdown of work units within complex programs, determination of sequences to be used in the performance of tasks, scheduling of interrelationships, and computation of time required to accomplish activities so that the end objective is completed within the resource and time constraints.

Successful school administrators followed something similar to PERT but did it intuitively or in a rather informal manner. As long as the project is not too complex it can be planned in the "well-organized head" of the successful school administrator. In a sense, PERT represents a formalized, verbalized, and sophisticated statement of an orderly approach for accomplishing a task.

An organized attack on a complex project by breaking it down into interrelated and meaningful tasks is the more familiar advantage of PERT. There is a mathematical dimension as well which shall be explored in greater detail in subsequent paragraphs.

PERT is basically a process. All processes must inevitably be tied to some substantive content. A person who is knowledgeable in a general technique but ignorant of the fundamental context of that which is to be subjected to the technique can hope for only limited success at best. PERT is not a substitute for knowledge gained through study and experience of the substantive problems confronting administrators. By the same token, one cannot comprehend the PERT process simply by concentrating on a substantive knowledge in a given field. Effectiveness is based on comprehending the nature of the PERT approach and also the knowledge of the fundamentals of the work to be "PERTed."

Success calls for a merger of the two rather than isolated skills in only one aspect of the total problem. It is a lot simpler for a school administrator to gain the skills and insights of PERT than it is for a "PERT expert" to achieve the skills and insights of all the problems confronting various types of administrators.

Particular milestones or events that signal the completion of a definable work unit are among the most essential elements of PERT. An event is a milestone or a definable and significant completed achievement. It is either the start or completion of a task. In itself it is instantaneous, a finite point in time, and requires no time or resources. Thus, final architectural drawings completed, interior walls painted, teachers hired, housing plans started, guide to the teaching of modern math completed, and so on, represent significant, definable, and measurable events.

The accomplishment of an event requires activity. Activities, in contrast to events, take time and consume resources. Thus, the event previously called "teachers hired" necessitated the activity of many principals reporting vacancies; the school personnel officer using such resources as time to think, paper and pencil, consultant services, and perhaps a copying machine; as well as the many administrators who reviewed credentials and interviewed candidates. Events and activities are very important building blocks in the utilization of PERT. Here again one notices the importance of understanding the subject matter of the program to be PERTed.

No event stands by itself, nor is any activity an end in itself. Events are related in a sequential fashion. A given activity cannot take place until the event (s) leading to it has been accomplished. Thus, it is difficult to produce final architectural drawings before the following events have occurred: architect employed, educational specifications completed, preliminary architectural drawings completed, and preliminary architectural drawings approved. In PERT the sequence of events and activities is important.

There have been other approaches, such as the Gantt Milestone Charts, which have been used for many years to ascertain progress toward the completion of a complex task. PERT is similar to the Gantt Charts in that both record the occurrence of the significant event or milestone and measure time to complete the activities leading to the milestone. PERT differs from the Gantt approach by indicating the sequential relationship of events and activities. In the case of school plant construction the significant and definable event of "roof installed" cannot occur until other events such as supporting structural systems or walls have been completed. These in turn must wait until footings have been completed. One does not start the pouring of footings before the site purchase and before architectural and engineering plans have been completed, and so on.

The measurement of elapsed time for activities leading from one event to another is a significant aspect of PERT. The time dimension helps to identify the critical path of work that leads to the end product or goal, and this in turn is useful in allocating resources to various activities in the total program as well as estimating whether work will be completed on schedule. Much of the usefulness of PERT would be destroyed if one failed to think of the time it takes to complete activities.

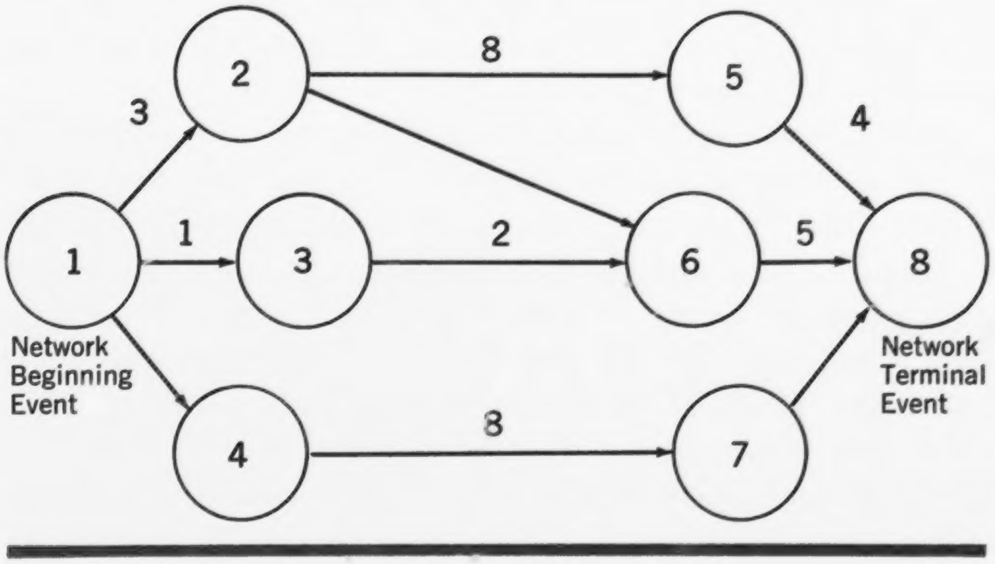
PERT Networks

A sequential pattern showing interrelated events and activities and culminating in the achievement of the end product is called the PERT network (or model, diagram, or schematic). The term "network modeling" is quite popular today. The PERT network is simply a diagram, sketch, or pattern which shows the events and activities, and time between them, required to attain the ultimate goal. Standard symbols are employed. Thus, all events are designated by a circle. Activities are denoted by an arrow leading from one event to another.

Events represent the significant units of work that must be accomplished if the end product is to be realized. A work breakdown is prepared with each milestone duly noted. Each specific milestone is numbered and the number inserted in the circle to facilitate preparation of the PERT network. Thus, there is usually a need for a legend or list describing the numbered events. The time it takes to complete an activity is placed above the activity line in the network.

The following is an illustration of a PERT network. It is presented in abstract form with numbers placed in circles to symbolize events.

FIGURE 1
A SIMPLE PERT NETWORK



What kinds of information can be gained from an analysis of Figure 1? First of all note that Event 2 is dependent upon the realization of Event 1 and the activity between them. Event 2 is independent of the accomplishment of Events 3 and 4. Activities 1–3 and 1–4 are parallel to Activity 1–2. (An activity is identified by the event numbers connected by the activity.) This is not true for all cases; to illustrate, Activity 1–3 and Activity 3–6 are series connected and not parallel. Note that Event 6 is dependent upon the completion of two prior Events (2 and 3) as well as Activities 2–6 and 3–6. The network terminal event is number 8. As was said before, a special list or legend would be needed to describe of what Events 2, 3, 6, and so on consist.

The time that it takes to accomplish activities is shown above the arrows connecting two events. This time is expressed in weeks or decimal fractions of weeks. In this particular case no decimal fractions are used. Thus, it takes three weeks to accomplish the activity designated as 1–2. Again keep in mind that the activity is identified by the beginning and ending event number. Activity 2–6 takes seven weeks, and Activity 4–7, eight weeks. This time is known more formally as "expected elapsed time" and designated by the symbol ʻe. This is a very important PERT concept and very useful in extracting more information from the network diagram.

One of the basic (and obvious) ground rules of PERT is that an event cannot be completed until all activities leading to it have been completed. Look at the activities leading to Event 6. As stated previously Event 6 is based upon the completion of Events 2 and 3 and two activities leading from them. Activity 1–2 requires three weeks and Activity 2–6, seven weeks. Therefore, following path 1–2–6 the activity time to accomplish Event 6 would total ten weeks. On the other hand, Activity 1–3 requires one week and Activity

3–6, two weeks. Three weeks is the total activity time to move from Event 1 to Event 6 following activity path 1–3–6.

Earliest Time Computations

Another important PERT concept is the earliest time for the completion of an event, symbolically designated as TE. Strange as it may seem, the "earliest time" is the "longest time" required for the execution of activities leading to an event. Accordingly, earliest time (TE) for completion of Event 6 is ten weeks rather than three weeks. Stated in general terms the earliest time an event can be completed is the longest time it takes to reach that event through any path leading to it. Stated another way, the earliest time (TE) an event can be completed is equal to the summation of the expected elapsed time (${}^{t}e$) for each activity via the longest time path to that event. In a certain sense the term "earliest time" is misleading. It implies "no sooner than" rather than the shortest time. It suggests that a given event cannot be completed before *all* the prior events and the activities from them have been completed. Some sources refer to TE as the "earliest expected date" rather than simply "earliest time" (which is best remembered as "longest time"). The problem of computing earliest time is simplified greatly if there is only one path leading to an event.

The mathematical dimension of PERT provides for certain computations which yield data useful in decision making concerning commitment of resources to certain activities. The mathematics involved is simple. It does not call for calculus or differential equations but is merely the basic arithmetic processes of addition, subtraction, and division. With simple mathematical manipulations it is possible to determine how long it takes to reach a network ending event, where slack time is available in the project, and how to identify the critical path.

Identifying the Critical Path

In Figure 1, Event 8 is the network ending event. There are four paths to it. All start with Event 1 and can be identified as path 1–2–5–8; path 1–2–6–8; path 1–3–6–8; and path 1–4–7–8. Earliest expected date (T_E) for completion of Event 8 is simply the cumulative addition of the expected elasped time (‘e) for each activity in any path leading to Event 8. The T_E must be computed for each path. The following computations apply to path 1–2–5–8: three weeks to complete Activity 1–2, eight weeks for Activity 2–5, and four weeks for Activity 5–8. This is a total of 15 weeks for execution of all activities on this particular path. The total activity time for path 1–2–6–8 is 15 weeks; for path 1–3–6–8, eight weeks; and for path 1–4–7–8, 18 weeks. It is apparent that the longest time path is 1–4–7–8 and, therefore, the earliest time (T_E), or earliest expected date, for Event 8 is 18 weeks.

These computations are related to the fundamental concept of "critical path." The critical path is defined as the path which requires the longest time to progress from the network beginning event to the network ending event. In Figure 1, as we just saw, 18 weeks are required to complete all activities along path 1–4–7–8 to reach Event 8. This is the longest time and, therefore, path 1–4–7–8 is the critical path in this particular network.

One reason why this path is labeled critical is that no slack time is available anywhere along the path. On path 1–2–6–8 there is three weeks of slack, because the completion of all activities on this path requires only 15 weeks.

Slack Time

The idea of slack time contributes much of value to administrators using PERT. Slack time is more difficult to compute and explain than previous concepts. One reason for this is that *two* other computations must be made before slack time can be obtained. The first is earliest time (T_E, or earliest expected date), explained previously. The second is "latest allowable date" which is designated by the symbol T_L. The computation of T_L begins with the *earliest* expected date for the network *ending* event. The mathematical manipulation works backward from the terminal to the network beginning event. The reason for this is that the earliest expected date for the network ending event is also its latest allowable date. In other words, for Event 8, $T_E = T_L$; keep in mind that computation of the latest allowable date (T_L) cannot proceed unless the earliest expected date (T_E) is known for the network ending event.

Slack is equal to the difference between the latest allowable date (T_L) for a given event and the earliest expected date (T_E) for that same event. The general rule is slack time $=$ $T_E - T_L$.

PERT and Decision Making

The expected elapsed time (te) for each activity, earliest expected date for each event (T_E), latest allowable date for each event (T_L), and slack time for each event ($T_E - T_L$) in Figure 1 are computed and arranged in Table 1. Note that no slack (zero slack) is found for all points on the critical path. Resources must be maintained for activities along the critical path. Some resources may be moved from events where slack time is available to where there is none. In this manner PERT can facilitate prudent decision making concerned with resource allocation and utilization.

TABLE 1
Computations of Slack Time for the PERT Network Shown in Figure 1

Activities	t_e	T_E	T_L	Slack Time $T_L—T_E$
1-2	3	3	6	3
1-3	1	1	11	10
1-4	6	6	6	0
2-5	8	11	14	3
2-6	7	10	13	3
3-6	2	3	13	10
4-7	8	14	14	0
5-8	4	15	18	3
6-8	5	15	18	3
7-8	4	18	18	0

With PERT networks the administrator can produce a model or picture of total operations and allocate resources necessary for the accomplishment of specific tasks on something other than pure hunches. In other words, important resource allocation decisions are given a mathematical basis.

PERT is a way of improving the ability of the administrator to stay on top of new projects. It is a way of comparing progress at a given moment with schedules developed earlier. Thus, if Activity 1–2 takes longer than the expected elapsed time, then it follows that unless additional resources are made available to reduce the time of activity leading to Event 7, the whole project will not meet the deadline. PERT's value to contractors working on school buildings should be apparent. Whether the building will be completed on the scheduled date can be determined months in advance if the project has been PERTed. Of course, the number of weeks or days the project will be delayed can be computed with comparative certainty as well. It should be stated, however, that PERT requires staff time, money, and additional funds for planning. The illustration of the simple PERT diagram is very much like CPM. No effort has been made to estimate the duration of an activity on the basis of most likely time, optimistic time, and pessimistic time. PERT is distinguished from other network modeling on the basis of these time estimates.

More Mathematically Oriented Applications of Operations Research

The AASA Commission recognized that many administrators found the preceding mathematical manipulations more than enough and would not be interested in the more quantitatively oriented applications of operations research. Others may be. For this latter group certain applications were placed at the end of this chapter. Those not interested in additional mathematical illustrations of operations research may elect to skip what follows in this chapter.

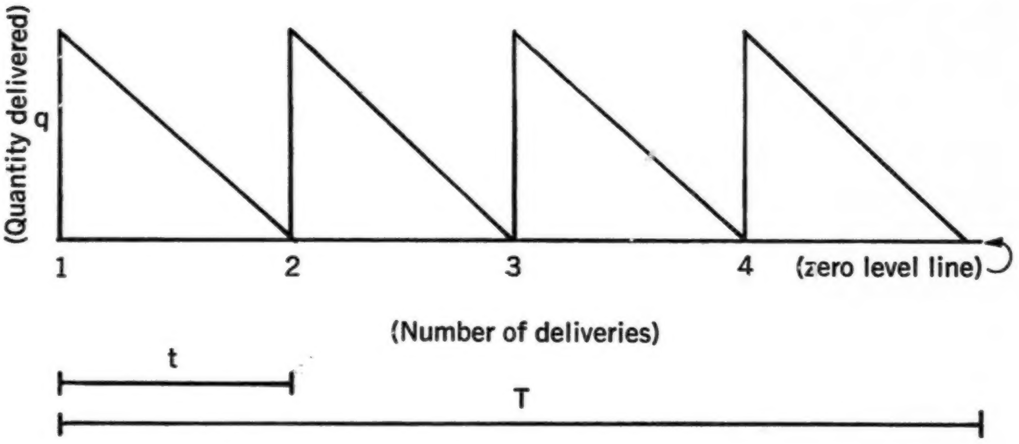
The systems technology used in industry to control inventories may be adapted to large school districts with central warehouses for school supplies and equipment. Thus, a central warehouse may be required to supply R units of certain instructional supplies at a constant rate to all schools during a time period designated as T. The demand is known and fixed. No shortages are to be permitted, lest the lack of these supplies interfere with instructional activities.

How often should the district order the necessary supplies and how many units should be ordered for each delivery to the warehouse to keep costs at a minimum? The key factors in the analysis of this problem are:

$I =$ inventory cost per unit of time
$S =$ cost per delivery to the warehouse
$R =$ total requirement such as total supply requirement for one school year

T = total time such as one school year
q = quantity requirements per delivery
t = time between deliveries from vendor to warehouse
C = total expected cost.

The manner in which the inventory of the instructional supplies in the central warehouse rises and falls is shown in the graph below. The letter q shows the inventory level of a given supply item immediately after each delivery from the vendor. During the time period t, the period between deliveries from the vendor, the supplies are used by the school staff or ordered from the school warehouse and, therefore, the inventory level approaches zero. After the second delivery the amount on hand rises once again to the q level, is used, and falls to zero over time; a third delivery is made to bring the supply to q once again, and so on.



The number of deliveries to the central warehouse from a vendor of school supplies is related to the total amount required during T (shown as R) divided by the amounts required for each delivery. This can be expressed as follows:

R/q = number of deliveries during T

$t = \frac{T}{R/q} = \frac{Tq}{R}$ (Stated another way: Number of deliveries during $T=N \ldots N=R/q$; $t = T/N$ or $t - Tq/R$)

$q/2$ = average inventory during t (interval begins with q units and ends with 0)

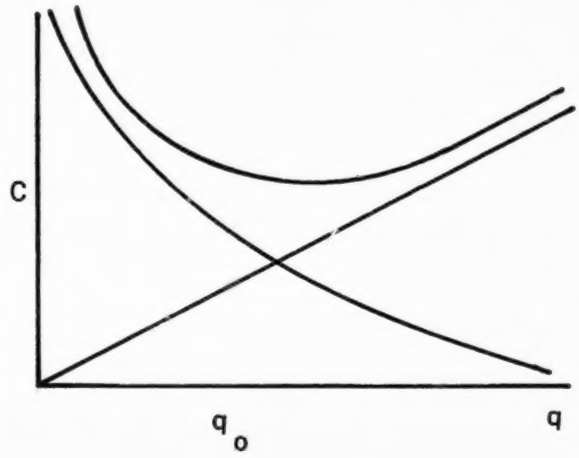
$\frac{q}{2}$ I t = inventory cost during t

$$C = \left(\frac{q}{2} I t + S\right)\frac{R}{q}$$

Substitute for t:

$$C = \left(\frac{q}{2} \frac{I T q}{R} + S\right)\frac{R}{q}$$

$$C = \frac{I T q}{2} + \frac{SR}{q}$$



To find q (the requirements for delivery) proceed as follows:

$$C(q) = \frac{1}{2} I T q + \frac{SR}{q}$$

$$\frac{d\,c(q)}{dq} = \frac{1}{2} IT - \frac{SR}{q^2}$$

Solve for q when derivative is 0:

$$\frac{SR}{q_o^2} = \frac{1}{2} I\,T$$

$$q_o^2 = \frac{2SR}{IT}$$

$$q_o = \sqrt{\frac{2SR}{IT}}$$

$$t_o = \frac{Tq_o}{R} = \frac{T}{R}\sqrt{\frac{2SR}{IT}} = \sqrt{\frac{2\,TS}{RI}}$$

$$C_o = \frac{ITq_o}{2} + \frac{SR}{q_o}$$

$$= \frac{IT}{2}\sqrt{\frac{2SR}{IT}} + \frac{SR}{\sqrt{\frac{2SR}{IT}}}$$

$$= \sqrt{\frac{ISTR}{2}} + \sqrt{\frac{ISTR}{2}}$$

$$C_o = \sqrt{2ISTR}$$

The school should therefore order $\sqrt{\frac{2SR}{IT}}$ items per delivery. An order should be placed every $\sqrt{\frac{2SR}{RI}}$ weeks. The minimum total cost for maintaining the inventory will be $\sqrt{2ISTR}$ dollars.

Game Theory

The theory of games has its origin in economics. The game is concerned with two opponents, each of whom is interested in either maximizing profits or minimizing losses. The strategy of the game is the complete game plan. The administrator may use this technique in resolving conflict situations. The value of the game is the amount won or lost in each game.

$$\begin{array}{c|c|c|}
 & C_1 & C_2 \\ \cline{2-3}
R_1 & & \\ \cline{2-3}
R_2 & & \\ \cline{2-3}
\end{array}$$

The strategies invoked by player C are C_1 or C_2; player R's strategies are R_1 or R_2. The payoff is the amount in the cell which C wins and R loses, or vice versa. Assume that for negative numbers R pays C and for positive numbers C pays R. This is shown in the following matrix:

$$\begin{array}{c|c|c|}
 & C_1 & C_2 \\ \cline{2-3}
R_1 & -1 & 1 \\ \cline{2-3}
R_2 & 1 & 1 \\ \cline{2-3}
\end{array}$$

Obviously if R plays strategy R_1 and C plays strategy C_1, then R will always win 1 (−1 means C loses); for all others C will always win 1. A system can be used in the matrix:

$$\begin{array}{c|c|c|c}
 & C_1 & C_2 & \\ \cline{2-3}
R_1 & -1 & 1 & 1 \\ \cline{2-3}
R_2 & 1 & 2 & 2 \\ \cline{2-3}
 & -1 & 1 &
\end{array}$$

(maximum value of each cell)

(minimum value of each cell)

At the end of each column denote the minimum cellular value; at the end of each row denote the maximum cellular value as above.

Check the rows and columns to see if a row maximum is equal to a column minimum. In the above example such is the case, and the game is said to have a saddlepoint. If a game has a saddlepoint, the problem is solved and each player should use that strategy associated with the saddlepoint. In the example above, C should always use C_1 and R should always use R_1.

If a saddlepoint does not exist then a mixed strategy is required. In that case one proceeds as follows:

	C_1	C_2	
R_1	5	2	5
R_2	1	3	3
	1	2	

(maximum value of each cell)

(minimum value of each cell)

For R_1 subtract C_2 from C_1 = 3

For R_2 subtract C_2 from C_1 = −2

For C_1 subtract R_2 from R_1 = 4

For C_2 subtract R_2 from R_1 = −1

	C_1	C_2	
R_1	5	2	3
R_2	1	3	−2
	4	−1	

Reverse the numbers and make all numbers positive:

	C_1	C_2	
R_1	5	2	2
R_2	1	3	3
	1	4	

C should play C_1 one-fifth of the time and C_2 four-fifths of the time; R should play R_1 two-fifths of the time and R_2 three-fifths of the time. The value of the game will be as follows:

$$V_C = 5\left(\frac{1}{5}\right) + 2\left(\frac{4}{5}\right) = \frac{5}{5} + \frac{8}{5}$$

$$= \frac{13}{5}$$

$$V_R = 5\left(\frac{2}{5}\right) + 1\left(\frac{3}{5}\right) = \frac{10}{5} + \frac{3}{5}$$

$$= \frac{13}{5}$$

R always loses $2\frac{3}{5}$

C always wins $2\frac{3}{5}$

Queuing Theory

Queuing theory has found its primary application in communications. It is most often used in waiting time models, which have implications for education in library circulation, cafeteria waiting lines, service times in maintenance shops, and so on.

The three basic pieces of information from queuing theory are mean waiting time $\bar{n}$, probability of n persons waiting in line P(n), and the mean waiting time tw. Assume an arrival rate (λ) of 5 per hour and a service rate (μ) of 10 per hour. Determine $\bar{n}$, P(n), and tw.

$$\bar{n} = \frac{\frac{\lambda}{\mu}}{1 - \frac{\lambda}{\mu}}$$

$$= \frac{\frac{1}{2}}{1 - \frac{1}{2}}$$

$$= 1$$

$$P(n) = \left(\frac{\lambda}{\mu}\right)^n \left(1 - \frac{\lambda}{\mu}\right)$$

What is the probability of two persons waiting in line?

$$P_{(2)} = \left(\frac{1}{2}\right)^2 \left(1 - \frac{\overset{\lambda}{1}}{2}\right)$$

$$= \left(\frac{1}{4}\right)\left(\frac{1}{2}\right)$$

$$= \frac{1}{8}$$

What is the mean waiting time for each person?

$$tw = \frac{1}{\mu - \lambda} - \frac{1}{\mu}$$

$$= \frac{1}{10-5} - \frac{1}{10}$$

$$= \frac{1}{5} - \frac{1}{10}$$

$= \frac{1}{10}$

$= .10$ of an hour

Summary

Systems work is now being applied to a variety of problems in education. The applications presented here are reasonably representative and are presented to give the reader a feel for the systems approach to on-line problems. The essential aspect of all systems applications involves specific problem orientation. Therein lies the payoff of the systems technology.

CHAPTER 7

Potentialities and Realities

The growing host of unresolved educational problems is testimony to the urgency of this need to improve decision making. Traditional approaches have been largely subjective and intuitive. Explicit analyses have not been possible for eliminating areas of shortcomings and substituting more effective processes.

This publication has attempted to explore additional alternative tools and procedures for use in administrative decision making. Various approaches and aids to more effective decision making have been discussed: operations research, PERT, cost-utility analysis, and PPBS. These generalized descriptive approaches often depend upon subsets of technical tools, such as linear programming, regression analysis, and probability theory. Although the use of computers is necessitated by some of the approaches, the emphasis of this publication has been on ways of thinking rather than on the hardware which might be utilized to facilitate various aspects of the decision-making process.

The ways of thinking which have been discussed emphasize explicit rational approaches which are future-output-oriented, aimed at the resolution of problems by analyzing cause-effect relationships utilizing technological tools. Basic in the use of administrative technology is the rejection of "authority" in the attempt to resolve problems. The recognition and definition of a particular problem represent the first steps in the use of administrative technology. Generalized labels such as "a serious problem" or "a complex situation" do little to aid in analysis of the key elements in a problem.

Because many of the approaches which have been discussed are new to administrators, there may be a tendency to ascribe magical attributes to them. Some may be tempted to hail them as the means of solving all problems in the "best" manner. Some may tend to regard the complete implementation of a total systems approach as the millennium in the decision-making process. In order to avoid such an overly optimistic attitude, it is important to recognize that none of the approaches discussed in this publication is capable in and of itself of making value judgments. Values and goals are subjective in nature and reflect a different level of reality from that which is subject to the objective tools and procedures which have been explored. For example, the operations research developed in England about thirty years ago did not indicate whether or not England should choose to defend herself in the event of an attack; the approaches used by the Department of Defense do not indicate whether or not the United States should continue to be engaged in the Vietnam conflict; in education, PPBS will not indicate whether or not a particular subject should be included in the curriculum.

Because the tools of modern technology are relatively more complex than those which are presently commonly utilized in education, and because specialized personnel are required in the development and implementation of many approaches, there is a danger that basic administrative decision making will be unknowingly delegated to the technologists who are employed because of their specialized competence. Even worse is the danger of systems being invaded by those who quickly pick up the jargon but fail to discipline themselves to acquire the more difficult techniques and procedures. They may generate negative reactions because of an inability to deliver on inflated promises. Each of the approaches discussed contains a series of basic administrative decisions, many of which should be the subject of top-level decision making rather than delegated to the technologists. For example, if management by exception is utilized in a particular system, the decision that 30 students will be the upper limit point and 20 students the lower limit point is one which should reflect the range of optimum size as perceived by top-level administration.

Many of the tools and procedures discussed are complex and require time and talent to adapt or develop and implement. It appears to be a natural tendency for the uninitiated to underestimate the sophistication, investment of resources, and time involved in analyzing, developing, and implementing particular systems or procedures. The emphasis upon the analysis of the specifics of the situation, the particulars of the output desired, and the need to develop generalizations based upon specifics preclude the indiscriminate application of a system developed for a business to a school system or for one school system to another school system. Local requirements tend to differ; goals differ; criteria of success generally differ. It should not be assumed that perfect models exist and that all that school administrators must do is to seek out and adapt these models. Such perfect models do not exist in any sphere of human activity.

Modern technology exacts a price from those who use it. New skills, concepts, and understandings must be developed. It is essential that consideration of the potentialities and realities of administrative technology be included in preparation programs for school administrators and in-service programs. Professional literature and workshops should be utilized not only to transmit the aura that administrative technology is useful and essential but to demonstrate successful uses of such technology. It is recommended that a series of AASA National Academy for School Executives programs be developed to disseminate the findings of this Commission and to demonstrate existing successful practices.

There are limited numbers of individuals who possess sufficiently developed capabilities in the tools and procedures which have been considered. As attempts to implement some of these approaches increase, the shortage of individuals with developed capabilities will increase. Inasmuch as most school administrators do not possess such capabilities, implementation of new approaches without sufficient capability invites almost certain failure.

There will be many school systems which will utilize the help of consultants. The qualifications and demonstrated capabilities of the consultants utilized are matters of prime importance. Consideration of the use of consultants must be coupled with consideration of the availability of personnel who will implement and operate the systems which are developed.

Recognition should be given to the probable increase in feelings of anxiety and inadequacy among those administrators who have not utilized the new approaches to problem solving. Exhortations calling for change and identification of promising practices will not prove sufficient. Therefore, coupled with the transmission of knowledge and information concerning administrative technology must be strategies for motivating attitudinal changes among administrators.

This chapter has attempted to place administrative technology within the context of its promise and its present-day limitations. Existing limitations should not preclude the more effective utilization of presently developed technology. There are risks in every new venture. The "debugging" process may be long and costly and perhaps even precipitate discontinuance of conceptually sound approaches. Systems capability cannot be developed overnight. Neither should limitations preclude exploration of the promsie of new tools and procedures. In other words, the dangers inherent in hasty implementation of systems should not be used as an excuse for doing nothing to develop new technology for school operations. Clearly, present administrative practices have severe limitations; clearly many school systems are unable to cope successfully with the vastly increased complexities which impinge upon them. The promise of the new technological approaches is too great to ignore. The course of the future of American education is dependent upon the successful development and implementation of new and more effective tools and procedures.

This publication should be viewed as only the beginning in the stimulation of the use of emerging technology to enhance the effectiveness of educational administration.

GLOSSARY:

Common Terms
Used in
Administrative Technology

ACTIVITY

The work effort involving time and resources required to complete a task or job to a given level of performance. It is represented on the network by an arrow and connects two network events.

ACTIVITY NETWORK

A network that uses activities rather than events as the basic building block.

ACTIVITY VARIANCE

A statistical statement of uncertainty based upon three time estimates for an activity using the following formula:

$$\sigma^2_t = \frac{(b - a)^2}{(6)}$$

ALGEBRA BOOLEAN

A process of reasoning, or a deductive system of theorems, using a symbolic logic and dealing with classes, propositions, or on-off circuit elements. It employs symbols to represent operators such as "and," "or," "not," "except," "if . . . then," etc., to permit mathematical calculation. Named after George Boole, famous English mathematician (1815-64).

ALGORITHM

A procedure for solving a problem or processing information in which the various steps, and their sequence, are specified beforehand.

BLACK BOX

A convenient term to describe a system component whose function is known, but whose mechanism is unspecified.

CONSTRAINT

A limitation or restriction imposed from outside on a decision maker. Constraints may be financial, physical, timing, or policy.

COST ACCOUNTING

That method of accounting used to establish all the elements of cost incurred to carry on an activity or operation.

COST-BENEFIT ANALYSIS

The process of examining and comparing alternative courses of action with respect to two main considerations: the cost in terms of needed resources, and the benefits (in general, the gains, utility, value, or effectiveness) in terms of the objectives to be attained. The results of the analysis can serve as one of the factors assisting the decision maker in a choice of alternatives.

CRITICAL PATH

That sequence of events and activities that has the greatest negative or least positive slack, or the longest path through the network.

CRITICAL PATH METHOD (CPM)

An activity-oriented network representation of the relationship and duration of tasks of an entire project. The longest path, in terms of time, through the project is known as the critical path. Each task on this path must be completed within the time allotted in order for the project to be completed on time. Tasks not on this path can have extra time for completion. Costs and resource availability can be associated with each task to give management a basis for a choice of schedules, and to monitor the project. Most projects use a combination of CPM-PERT.

CYBERNETICS

The field of technology involved in the comparative study of the control and intracommunication of information-handling machines and the nervous systems of animals and man in order to understand and improve communication.

DATA

A general term used to denote any or all facts, numbers, or letters and symbols that refer to or describe an object, idea, condition, situation, or other factor. It connotes basic elements of information which can be processed or produced by a computer. Sometimes data are considered to be expressible only in numerical form, but information is not so limited.

DATA PROCESSING

A series of operations used for handling information. Data processor may be defined as any group of people and/or machines organized and acting together to perform the processing of information.

DYNAMIC PROGRAMMING

A mathematical technique for use in situations in which the allocation of resources is made in a sequence of decisions over time and the objective is to obtain the maximum return over the entire sequence of decisions.

EVENT

A specific, definable accomplishment in a program network, which is recognizable at a particular instant in time. Events do not consume time or resources. They are usually represented on the network by circles.

EVENT SLACK

The difference between the Earliest Expected Date (T_E) and the Latest Allowable Date (T_L) for a given event. If the T_E for an event is later than T_L, the event is said to have negative slack. When the T_L is later than the T_E, the event is said to have positive slack.

EXPECTED ELAPSED TIME

The time which an activity is predicted to require based on the formula:

$$t_e = \frac{a + 4m + b}{6}$$

Expected Elapsed Time is usually represented by the symbol t_e and has a 50-50 chance of being equaled or exceeded in practice.

FEEDBACK

Procedures, built into a system, which provide information on how well the actual performance of the system matches the planned performance.

FLOW CHART

A pictorial description of a plan showing the interrelationships of all required events. It is also called a network, arrow diagram, etc.

GAMING

A simulation of competitive processes in which strategies are chosen mathematically. A game is specified by the number of players, the established rules for play, and a set of end conditions with which payoffs are associated.

HEURISTIC PROGRAMMING

The use of computer programs to carry out complex information processing by attempting to simulate the process by which humans solve problems. Stored in the computer are a number of separate programs for performing small identifiable tasks. Which tasks will be performed, and in what sequence, is not determined beforehand but rather under the control of the simulation program while the problem solving is in process.

INFORMATION RETRIEVAL

A method of cataloging vast amounts of related data so they can be called up any time they are needed, with speed and accuracy. The recovery of desired information or data from a collection of documents or other graphic records.

INFORMATION THEORY

A mathematical theory describing the efficiency of the transmission of information through a communications channel.

LINEAR PROGRAMMING

A mathematical technique for optimizing the overall allocation of resources to various activities where restrictions are such that not all activities can be performed optimally. A requirement is that the relationship between the activities and the restrictions and objectives be linear in a mathematical sense. The objective is to maximize or minimize some function. The decision problem is solved by finding the levels of the various activities that maximize (or minimize) the objective function while satisfying all restrictions.

MANAGEMENT

Its function is to decide on the most effective expenditure of manpower, facilities, materials, and funds needed to achieve the objectives.

MILESTONES

Key program events, the accomplishment of which are essential to the completion of a program. A milestone is usually represented on the network by a rectangle or square.

MODEL, MATHEMATICAL

The general characterization of a process, object, or concept in terms of mathematics which enables the relatively simple manipulation of variables to be accomplished in order to determine how the process, object, or concept would behave in different situations.

MONTE CARLO METHODS

The use of sampling methods to solve mathematical problems involving a random variable. An example is observing the pattern of winning numbers on a roulette wheel, developing a mathematical model that describes the bias of the wheel, and then testing the model by attempting to predict the winning numbers during actual play.

MOST LIKELY TIME

The most realistic estimate of the time an activity might consume in the opinion of the estimator. It is usually represented by the symbol (m). This time would be expected to occur more often than any other time if the activity could be repeated many times under the same circumstances.

NETWORK

A flow diagram consisting of activities and events which must be accomplished to reach the program objective. The flow diagram shows the planned sequences of accomplishment, interdependencies, and interrelationships of the activities and events.

OPERATIONS RESEARCH (OR)

The use of analytic methods adopted from mathematics for solving operational problems. The objective is to provide management with a more logical basis for making sound predictions and decisions. Among the common scientific techniques used in operations research are the following: linear programming probability theory, information theory, game theory, and Monte Carlo method.

OPTIMISTIC TIME

The time in which an activity can be accomplished or completed if everything goes extremely well. It is represented by the symbol (a). An activity may have one chance in a hundred of being completed within this period.

OPTIMIZATION

A strategy to maximize objectives. If there is one objective, or multiple independent objectives, which do not vary with time, then optimization may be possible. When objectives are dependent, or vary with time, maximizing one objective usually results in suboptimization in which there is less than maximum attainment of the other objectives.

PERT

An acronym for program evaluation and review technique. An event-oriented network representation of the time and duration of tasks of an entire project. An event is a point in time marking the start or completion of a task. PERT uses three time estimates for each task—optimistic, pessimistic, and most probable. The probability of meeting scheduled dates can then be calculated to assist management in evaluating project status. Most projects use a combination of PERT-CPM.

PPBS

An abbreviation for the planning-programming-budgeting-system. A decision system for allocating resources to various objectives based on cost-effectiveness analysis.

PAYOFF

In a game, the amount gained by one player and lost by another in a given move.

PESSIMISTIC TIME

An estimate of the longest time an activity would require under the most adverse conditions. It is usually represented by the symbol (b). An activity may have one chance in a hundred of being completed within this period.

PROBABILITY

A statistical statement of the likelihood of occurrence of a particular event in the network. It is represented by the symbol P_R.

PROBABILITY THEORY

A mathematical tool useful to the decision maker who is forced to make decisions in the face of uncertainty as to what will happen after the decision is made.

PROCESSING DATA

(1) The preparation of source media which contain data or basic elements of information and the handling of such data according to precise rules of procedure to accomplish such operations as classifying, sorting,

calculating, summarizing, and recording. (2) The production of records and reports.

PROGRAM BUDGETING

The preparation of a budget which reflects explicit consideration of present and future costs of various programs designed to realize objectives. It is essentially a task of determining priorities for the various objectives, because of limitations on resources, in order to achieve a coherent program of action for the government as a whole. A programmatic classification system for budget accounts. Sometimes equated with PPBS.

RELIABILITY ANALYSIS

Based on statistical analyses of educational tests (for example), the reliability of the result is that part which is due to permanent systematic effects and therefore persists from sample to sample, as distinct from error effects which vary from one sample to another.

RESOURCE

An available means whose store is reduced in quantity through use. Resources can be financial, facilities, equipment, material, or personnel.

SAMPLING THEORY

A mathematical description of the processes by which a specified part of a whole population is deliberately selected as representative of the whole for the purpose of investigating the properties of the whole.

SCHEDULED COMPLETION DATE

A date assigned for completion of an activity or event for purposes of planning and control. It is usually represented by the symbol T_S. Where no specific date is assigned, S_E equals T_S.

SERVO THEORY

A mathematical description of the processes by which automatic control of an operating system is maintained. When the system varies from specified performance, the error is detected and, through a feedback process, timely corrective procedures are automatically instituted in the system to eliminate the error.

SIMULATION

The study of realistic systems through the use of analogous models. The application of computer methods to mathematical models permits many possible system variations to be examined in a relatively short span of time.

SLACK

The difference between the Latest Allowable Date and the Earliest Expected Date (T_L–T_E). It is also the difference between the Latest Completion Date and the Earliest Completion Date (S_L–S_E). Slack is a characteristic of the network paths. Slack may be positive, zero, or negative.

STANDARD DEVIATION

A statistical statement of variability about the expected completion date of an activity. Common PERT practice uses a standard deviation equal to one-sixth of the difference between the Optimistic and Pessimistic Time Estimates.

$$\sigma = \frac{b - a}{6}$$

STRATEGY

Choice of a specific course of action or a specific utilization of resources by a decision maker.

SYSTEM

An organized assemblage of interrelated components designed to function as a whole to achieve a predetermined objective.

SYSTEM, INFORMATION

The network of all communication methods within an organization. Information may be derived from many sources other than a data-processing unit, such as by telephone, by contact with other people, or by studying an operation.

SYSTEM, INFORMATION RETRIEVAL

A system for locating and selecting, on demand, certain documents or other graphic records relevant to a given information requirement from a file of such material. Examples of information retrieval systems are classification, indexing, and machine-searching systems.

SYSTEM, MANAGEMENT INFORMATION

A communications process in which data are recorded and processed for operational purposes. The problems are isolated for higher-level decision making, and information is fed back to top management to reflect the progress or lack of progress made in achieving major objectives.

SYSTEMS APPROACH

A rational procedure for designing a system for attaining specific objectives. The methodology includes specification of objectives in measurable terms; restatement of the objectives in terms of capabilities and constraints; development of possible approaches; selection of appropriate approaches as a result of a trade-off study; integration of the approaches into an integrated system;

evaluation of the effectiveness of the system in attaining objectives.

TASK

A related group of activities that clearly defines a segment of a program. Small programs may be considered as one task, while a system program may have a hundred or more. Tasks in a program are relatively stationary, while activities are dynamic.

TIME ESTIMATE

An estimate of time required to perform an activity, based upon technical judgment, experience, and knowledge of the job. Time estimates are not commitments or schedules.

TRADE-OFF

The weighing, on the basis of selection criteria, of the use of alternative approaches to attain an objective, with the intent to select a "best" alternative. Appropriate criteria, with differing relative importance, might include performance, timing, risk, cost-benefit, or policy.

WORK BREAKDOWN STRUCTURE

A family tree subdivision of a project beginning with the end objective which is then subdivided into successively small units. The work breakdown structure establishes a framework for defining work to be accomplished, constructing a network plan, and summarizing the cost and schedule status of a project for progressively higher management levels.